SAN FRANCISCO BAY AREA RAPID TRANSIT DISTRICT

BART STANDARD SPECIFICATIONS
R3.2.1

SEPTEMBER 2022

BFS R3.2.1 STANDARD SPECIFICATIONS

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SECTION 01 11 00

SUMMARY OF WORK

Note: This Section is to be used only as a guide. Users are expected to create the complete Section and insert it into the Contract Book.

[Editor's comments are italicized.]

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Contract Documents.

B. Contract Description.

C. Measurement and Payment.

D. Scope of Work.

E. Contract Limits.

F. Site Access.

G. Hours of Work.

H. Contract Duration.

I. Contract Liquidated Damages.

J. Hazardous Materials Warning (When applicable).

K. District Support (When applicable).

L. Interfaces with Other Agencies and Contractors (When applicable).

M. Permits (When applicable).

N. Temporary Storage of Materials and Laydown Area (When applicable).

O. Incentives (When applicable).

1.02 CONTRACT DOCUMENTS

A. The Work shall be performed and completed in accordance with the following documents:

1. The General Conditions for Construction *(Procurement)* Contracts and the Supplementary Conditions; the Contract Specifications which invoke, modify, and augment the Standard Specifications; and the various forms and exhibits; all contained in the Contract Book.

2. The BART Facilities Standards, Standard Specifications, Release Rx.x, dated xxxx 20xx, on Compact Disc (CD) or available for download on-line at www.bart.gov/about/business/specifications. In accordance with the General Conditions Article GC1, the Standard Specifications are applicable to the Work to the extent referenced in the Contract Specifications.

3. The Contract Drawings [*Note, if there are Reference Drawings, add "and Reference Drawings" and state whether Reference Drawings are bound with the Contract Drawings or Contract Book, or bound separately*.]

1.03 CONTRACT DESCRIPTION

A. *[Provide a short summary of contract description which identifies the work locations and* principal *work elements (this paragraph is typically copied and placed in the Invitation to Bidders, so be brief).]*

1.04 MEASUREMENT AND PAYMENT

A. Separate measurement and payment will not be made for work required under this Contract Specifications Section. All costs in connection therewith will be considered incidental to the item of work to which they pertain.

1.05 SCOPE OF WORK

A. *[Provide a detailed description or list of the major work elements. This should include discussion of work being done outside BART property including work that must be staged.]*

1.06 CONTRACT LIMITS

A. Contract limits are described in the Contract Drawings. *[Additional text can be added to define the physical boundaries of the Jobsite. Any impacts or constraints to adjoining Right of Way, Easement restrictions or impacted third party facilities should be reflected here.]*

1.07 SITE ACCESS

A. The Contractor's access to the Jobsite shall be coordinated with the Engineer.

B. Contractor shall comply with the following Specifications and requirements prior to performing any physical work on the Jobsite:

1. Section 01 32 16, Construction Progress Schedules

2. Section 01 33 00, Submittal Procedures

3. Section 01 35 14, Operating System Interface

4. Section 01 35 24, Construction Safety

5. Section 01 35 54, Identification and Security

6. Section 01 43 00, Quality Assurance and Quality Control

7. Section 01 57 00, Temporary Controls

8. *Permits (When applicable)*

C. Access to District facilities will only be permitted provided the Contractor has received approval. Access shall be primarily for purposes of mobilization. Additional Jobsite activities require approval of the Baseline Schedule or approval of the Baseline Schedule's initial activities.

D. Work shall be scheduled and performed only in accordance with a District approved Site Specific Work Plan (SSWP) as indicated in Section 01 35 14, Operating System Interface and the Hours of Work specified herein*. [In Section 01 35 14 include restrictions that will affect means and methods.*

Provide any additional site access restrictions, such as limits to the number of simultaneous work locations, or defining certain activity restrictions such as work to be performed only during non-revenue. Issues identified in the SSWP cannot be captured in the Bid. The SSWP comes after the bid.]

E. The District's elevators and escalators shall not be used unless approved by the Engineer.

F. The Contractor shall not interfere in BART Revenue Operations (unless authorized by a District approved SSWP) and shall comply with security and safety procedures in accordance with these Contract Specifications and as directed by the Engineer.

G. *[Provide any additional information that a local agency may require for access to BART facilities or work/staging.]*

H. *[Include an offsite work permit requirements or restrictions.]*

I. *[Include copies of easements that may impact the work or description of easement restrictions that may impact the work. e.g. working in the Port of Oakland Property.]*

1.08 HOURS OF WORK

A. Regular construction work shall be performed between the hours of 7:00 a.m. and 7:00 p.m., on weekdays. [*This shall be modified to meet the project needs.]*

B. *[Clarify restrictions, e.g. work to be done at night only or during specific hours/.]*

C. Non-revenue hours are from: [*Confirm hours with Operations. Exact hours are different for each location.]*

[1:30 a.m. to 3:30 a.m. during weekdays

1:30 a.m. to 5:30 a.m. on Saturday

1:30 a.m. to 7:00 a.m. on Sunday]

D. Work shall not be performed on Saturdays, Sundays or District holidays without prior approval from the Engineer. District-recognized holidays are as follows:

1. New Year's Day – January 1
2. Dr. Martin Luther King, Jr. Day – First Monday after January 15
3. President's Day – Third Monday in February
4. Memorial Day – Last Monday in May
5. Independence Day – July 4
6. Labor Day – First Monday in September
7. Veterans Day – Second week in November
8. Thanksgiving Day, fourth Thursday in November
9. Christmas Day – December 25

E. Exceptions to the above hours of work will be permitted only upon written authorization from the Engineer.

F. *[Include restrictions that will be imposed by any local agency.]*

1.09 CONTRACT DURATION [IF APPLICABLE ADD "AND MILESTONES"]

A. Contract Completion Time: Pursuant to Article GC8.3 of the General Conditions, the Contractor shall commence Work on the date specified in the Notice to Proceed (NTP) and shall achieve Substantial Completion of Work within XXXX Days.

B. *[If applicable, define any intermediate milestone durations or additional Days if options or additive bid items are awarded.]*

C. *[If applicable, list required Operation and Maintenance Manuals and their scheduled milestones.]*

1.10 CONTRACT LIQUIDATED DAMAGES

[Indicate the liquidated damages for total Contract duration and any intermediate milestone liquidated damages. The values of the liquidated damages listed below are samples and should be calculated by the District Project Manager for each contract.]

A. Liquidated Damages: The amount of liquidated damages that will be assessed under the provisions of Article GC8.4.1 of the General Conditions is $X,XXX per Day for each Day's delay in achieving Substantial Completion of the Work, within the time specified in Article 1.09, above.

B. *[Optional, if needed.]* Liquidated Damages for Milestones specified in Article 1.09: The amount of liquidated damages that will be assessed under the provisions of

Articles GC8.4.1 of the General Conditions for each intermediate milestone per Day for each Day's delay in completing the milestone, within the time specified in Article 1.09, above.

1. Milestone 1: $X,XXX per Day.

2. Milestone 2: $X,XXX per additional weekend or partial weekend.

C. Liquidated Damages for Interruption of Revenue Operations: In the event that Revenue Operations are delayed or shut down due to Contractor's construction operations, including but not limited to, when such delays or shut down is due to Contractor's failure to complete scheduled activities by the planned time or Contractor's failure to put in place and implement an approved contingency plan so that the Jobsite is available for BART's Revenue Operations, the Contractor will be assessed liquidated damages as follows:

[Confirm appropriate values with Operations Planning or Operations Liaison]

1. $X,XXX for the first hour or part thereof

2. $X,XXX for the second hour or part thereof

3. $X,XXX for the third hour or part thereof

4. $X,XXX for the fourth hour or part thereof

5. $X,XXX per hour thereafter

D. [*Optional, if needed*] Liquidated Damages for Operations and Maintenance Manuals: Failure of the Contractor to obtain approval and deliver the required Operation and Maintenance manuals within the required schedule will make the Contractor liable for Liquidated Damages, The amount of Liquidated Damages that will be assessed for the late delivery to the District of the required manuals is $X,XXX per Day. *(Delivery of O&M Manuals should be associated with specific milestones.)*

E. Liquidated Damages for failure to implement BART Police Recommendations: Refer to Section 01 35 33, Security Procedures. If the Contractor fails to implement BART Police recommendations, the amount of Liquidated Damages that will be assessed is $X,XXX for each crime incident.*[This information is project specific and shall be obtained from BART Police.]*

F. Liquidated Damages for each milestone listed above are separate and cumulative.

1.11 HAZARDOUS MATERIALS WARNING *[WHEN APPLICABLE]*

A. *[Describe if Contractor has risk of exposure to known or suspected hazardous materials and reference applicable sections. This Article is not intended to cover unknown hazardous materials. Users are referred to General Conditions Article GC4.6, which specifies Contractor's actions when Contractor suspects hazardous materials are not identified in the Contract.]*

1.12 DISTRICT SUPPORT [*WHEN APPLICABLE]*

A. *[Provide description of assistance to be provided by District forces or equipment such as use of high rail equipment.]*

B. For additional requirements refer to Section 01 35 14, Operating System Interface. Employee in Charge (EIC): For work in the Operating Envelope, the District will assign and provide EIC(s) as specified to support the Contractor's work.

C. The District will assume the cost for XXXX hours of EIC support. The actual incurred cost of the EICs beyond these hours shall be the responsibility of the Contractor and will be deducted from the value of the progress payments through the issuance of a Change Order. The rate for EICs is $XXXX per hour per EIC with a minimum of 8 hours per shift. The rate for EICs is $XXXX per hour for all hours after the first 8 hours in a shift. The Contractor shall include on its invoice the number of EIC hours utilized during the invoice period in accordance with Article 1.06, Contract Payments of Section 01 20 00, Price and Payment Procedures. *[The number of hours is project specific. The hourly rate shall be obtained from M&E.]*

D. District On-Rail Maintenance Vehicles: The District will assign and provide on rail vehicles and drivers as specified to support the Contractor's work. The Contractor shall submit a notice in writing to the Engineer requesting the on-rail vehicle support prior to submitting request for Track Allocation as specified in Section 01 35 14, Operating System Interface. Request shall include the number of on-rail vehicles needed, date, and time on-rail vehicles will be required. The Contractor shall include on its invoice the number of on-rail vehicle driver hours utilized during the invoice period in accordance with Article 1.06, Contract Payments of Section 01 20 00, Price and Payment Procedures. The District will assume the cost for XXXX hours of on-rail vehicle support. The cost of on-rail vehicle support beyond these hours shall be the responsibility of the Contractor and will be deducted from the value of the progress payment through the issuance of a Change Order. The rate for on-rail vehicles is $XXXX per hour per vehicle with a minimum of 8 hours per shift. *[The rate varies depending on equipment and man-power requirements. The hourly rate shall be obtained from M&E.]*

E. Safe Clearances: The District will provide Safe Clearance support of electrified third rail sections as specified to support the Contractor's work. Contractor shall submit a notice in writing to the Engineer requesting the support prior to submitting request for Track Allocation as specified in Section 01 35 14, Operating System Interface. The Contractor shall include on its invoice the number of District supported Safe Clearances during the invoice period in accordance with Article 1.06, Contract Payments of Section 01 20 00, Price and Payment Procedures. The District will assume the cost for XXXX number of Safe Clearances occurrences. The cost of Safe Clearance support beyond this number of Safe Clearances occurrences shall be the responsibility of the Contractor and will be deducted from the value of the progress payment through the issuance of a Change Order. The rate for Safe Clearances is $XXXX per occurrence which includes the installation and removal of the Safe Clearance. *[The rate varies depending on equipment and man-power requirements. The hourly rate shall be obtained from M&E]*

F. Cancellations: The Contractor shall notify the District of any cancellation of the above support at least two (2) Working Days in advance of the start of such support to avoid the cost of District support. Cancellations of EICs, on-rail vehicles, or Safe Clearances, made less than two (2) Working Days in advance of the requested support will be considered District supported hours worked.

G. District reserves the right to cancel any approved District Support at any time due to unforeseen circumstances.

1.13 INTERFACE WITH OTHER AGENCIES AND CONTRACTORS [*WHEN APPLICABLE]*

A. Non-BART Facility Standards: Work on non-BART facilities shall be performed in accordance with the jurisdictional authorities' standard drawings and specifications. The Contractor shall obtain such standards as specified and comply with them as applicable.

B. *[Describe Contractor's responsibility and awareness to coordinate with other agencies or contractors.]*

1.14 PERMIT [WHEN APPLICABLE]

A. *[Refer to General Conditions Article 7.4, Permits and Licenses, which provides that the Contractor is responsible for all permits and their costs. Specify known permits that the Contractor must obtain and the permitting authorities. Make Article clear that the list of permits may not be all inclusive. Most work does not require permits on District property since the District is typically the authority having jurisdiction. If any permits are to be paid for by the District, then the Supplementary Conditions need to modify General Conditions Article GC7.4.]*

1.15 TEMPORARY STORAGE OF MATERIALS AND LAYDOWN AREA [*WHEN APPLICABLE*]

A. Refer to Contract Specifications Section 01 52 00, Construction Facilities, for storage provisions.

B. *[Describe any laydown areas and associated restrictions.]* The Contractor may include in SSWPs a request in writing for material storage on District property which shall be subject to District approval.

C. Material storage and laydown areas shall be in compliance with Section 01 57 00, Temporary Controls for EPA, Storm Water Pollution Prevention Plan or Water Pollution Control Plan compliance pursuant to GC7.10 Environmental Compliance.

1.16 INCENTIVES (W*HEN APPLICABLE*)

A. *[Describe any monetary incentives for early completion, including detailed description of measurement of incentive.]*

PART 2 – PRODUCTS

Not Used

PART 3 – EXECUTION

Not Used

END OF SECTION 01 11 00

SECTION 01 20 00

PRICE AND PAYMENT PROCEDURES

PART 1 – GENERAL

1.01 DESCRIPTION

A. This Section includes specifications for measurement and payment as they apply to the Work, and includes provisions applicable to lump sum prices, unit prices, and allowances, as indicated.

B. Measurement methods specified in the individual Sections of these Specifications shall govern if they differ from methods specified in this Section.

1.02 LUMP-SUM MEASUREMENT

A. Lump-sum measurement will be for the entire item, unit of work, structure, or combination thereof, as specified and as indicated in the Bid Schedule of the Bid Form.

1. If the Contractor requests progress payments for lump-sum items or amounts in the Bid Schedule, such progress payments will be made in accordance with a Schedule of Values, a well-balanced, detailed program of payment-apportioning. Such Schedule of Values shall be prepared by the Contractor and submitted to the Engineer for approval within seven Days of the effective date of the Notice to Proceed. Such Schedule of Values may require modifications during the Contract, as determined by the Engineer.

2. Such Schedule of Values for each applicable lump-sum item shall show fixed definable and measurable quantities where possible and unit prices there for as developed and assigned by the Contractor to the different features of the work and major subdivisions thereof. The Schedule of Values shall include a fair and reasonable value for As-Built drawings, and as applicable, values for O&M manuals, training, and spare parts. The summation of extensions of quantities and unit prices and related costs shall equal the amount of the lump-sum Contract Price or lump sum bid item indicated in the Bid Schedule.

3. Following the Engineer's approval, progress payments will be made in accordance with the Contractor's Schedule of Values and from the approved progress schedule, reflecting the progress which occurred during the payment period as approved by the Engineer.

1.03 MEASUREMENT OF QUANTITIES FOR UNIT PRICES

A. Measurement Standards:

1. All work to be paid for at a Contract price per unit measurement, as indicated in the Bid Schedule, will be measured by the Engineer in accordance with United States Standard Measures.

2. A ton shall consist of 2,000 pounds avoirdupois.

B. Measurement by Weight:

1. Reinforcing steel, steel shapes, castings, miscellaneous metal, metal fabrications, and similar items to be paid for by weight shall be measured by scale or by handbook weights for the type and quantity of material actually furnished and used.

2. Unless shipped by rail, material to be measured and paid for by weight shall be weighed on sealed scales regularly inspected by the State Division of Measurement Standards or its designated representative, furnished by and at the expense of the Contractor. All weighing, measuring, and metering devices shall be suitable for the purpose intended and shall conform to the tolerances and specifications as outlined in the California Code of Regulations, Title 4, Chapter 9, Division 5.

3. Provide or utilize platform scales of sufficient size and capacity to permit the entire vehicle or combination of vehicles to rest on the scale platform while being weighed. Combination vehicles may be weighed as separate units provided they are disconnected while being weighed. Scales shall be inspected and certified as often as the Engineer may deem necessary to ascertain accuracy. Costs incurred as a result of regulating, adjusting, testing, inspecting, and certifying scales shall be borne by the Contractor.

4. A licensed weighmaster shall weigh all materials weighed on scales furnished by the Contractor. The Engineer may be present to witness the weighing and to check and compile the daily record of such scale weights. However, in any case, the Engineer will require that the Contractor furnish weight slips and daily summary weigh sheets. In such cases, furnish a duplicate weight slip or a load slip for each vehicle weighed and deliver the slip to the Engineer at the point of delivery of the material.

5. If the material is shipped by rail, the certified car weights will be accepted, provided that only actual weight of material will be paid for and not minimum car weights used for assessing freight tariff. Car weights will not be acceptable for material to be passed through mixing plants. Material to be measured by weight shall be weighed separately for each bid item under which it is to be paid.

6. Trucks used to haul material being paid for by weight shall be weighed empty daily and at such additional times as the Engineer may require. Each truck shall bear a plainly legible identification mark. The Engineer may require the weight of the material verified by weighing empty and loaded trucks on such other scales as the Engineer may designate.

C. Measurement by Volume:

1. Measurement by volume will be by the cubic dimension indicated in the Bid Schedule. Method of volume measurement will be by the unit volume in place or removed as shown on the Contract Drawings or as specified.

2. When material is to be measured and paid for on a volume basis and it is impractical to determine the volume by the specified method of measurement, or when requested by the Contractor in writing and accepted by the Engineer in writing, the material may be weighed in accordance with the requirements

specified for weight measurement. Such weights will be converted to volume measurement for payment purposes. Factors for conversion from weight measurement to volume measurement will be determined by the Engineer and shall be agreed to by the Contractor before such method of measurement of pay quantities will be accepted.

D. Measurement by Area: Measurement by area will be by the square dimension shown on the Contract Drawings or as specified. Method of square measurement will be as specified.

E. Linear Measurement: Linear measurement will be by the linear dimension listed or indicated in the Bid Schedule. Unless otherwise indicated, items, components, or work to be measured on a linear basis will be measured at the centerline of the item in place.

F. Field Measurement for Payment:

1. The Engineer will compute all quantities of work performed by the Contractor on a unit-price basis, for payment purposes.

2. The Contractor shall assist the Engineer in the taking of measurements by providing all equipment, workers, and survey crews as required to measure quantities in accordance with the provisions for measurement specified herein and in Section 01 71 23, Field Engineering. Unless otherwise specified, all quantities shall be calculated using dimensions shown on the Contract Drawings. No allowance will be made for specified tolerances.

1.04 VALUES OF UNIT PRICES

A. The number of units and quantities contained in the Bid Schedule as estimated quantities are approximate only, and final payment will be made for the actual number of units and quantities which are incorporated in the Work and required by the Contract, as measured by the Engineer.

B. In the event that work or materials or equipment are required to be furnished to a greater or lesser extent than is indicated in the Contract Documents, such work or materials or equipment shall be furnished in greater or lesser quantities in accordance with General Conditions Article GC4.5, Increased or Decreased Quantities.

1.05 ALLOWANCES

A. Description: Allowances specified in the Contract Documents and indicated in the Bid Schedule shall cause the work so covered to be furnished, performed, and completed for such sums as are acceptable to the Engineer and shall include the cost to the Contractor of all materials and equipment to be delivered and installed under the specified Allowances.

B. Specific Allowances: Specific Allowances, if any, included in the Contract are specified in Contract Specifications Section 01 20 00, Price and Payment Procedures, and are indicated in the Bid Schedule.

C. Administration:

1. The Allowances specified in the Contract Specifications and indicated in the Bid Schedule are exclusive of any work indicated in the Contract Documents for which payment is included under other specifically designated items in the Bid Schedule.

2. The Contractor may not proceed with any work under an Allowance, or receive payment for such work unless directed to do so by the Engineer using a Change Notice as described in General Conditions Article GC4.2.1.1. The cost of the work shall either be an amount agreed upon by the Engineer and the Contractor, or an amount specified by the Engineer that the Contractor may not exceed without further direction from the Engineer.

3. Unless compensation for allowance work is agreed upon, a Force Account Daily Report form shall be used to track and record actual expenditures and expenses related to each allowance. Authorization for payments to the Contractor will be based on such Daily Reports and a related progress schedule. Payment may be made to the Contractor for amounts authorized by Change Notice, unless the total amount authorized exceeds the value of the Allowance indicated in the Bid Schedule.

4. Upon Acceptance of the Work, a Change Order will be prepared, reflecting the exact amount due to the Contractor if different from the exact amounts stated in the Bid Schedule for the specified Allowances.

1.06 CONTRACT PAYMENTS

A. Progress Payments:

1. Invoice for Work Completed: Not more than once each month the Contractor shall submit to the Engineer a proposed invoice for work performed or completed on forms supplied by the Engineer for evaluation and approval by the Engineer. The proposed invoice shall be certified, and shall be supported by evidence as required by the Engineer, that the work invoiced has been completed in accordance with the requirements of the Contract. The proposed invoice shall be submitted with, among other things, current certified payroll records (submitted weekly and within seven (7) Days after the regular payment date of the payroll period), proof of payment to Subcontractors, satisfactory Construction Progress Schedule and Monthly Progress Reports. As part of the proposed invoice submission, the Contractor shall also include a copy of the form obtained from BART's designated website for electronic submittal of certified payroll records with the names of Subcontractors that invoiced the Contractor during the payment application period, the amount invoiced by each Subcontractor, and the period during which the work included on the invoice was performed. This form with the above referenced Subcontractor payment information shall be approved by the Engineer once completed on BART's designated website for electronic submittal of certified payroll records. Failure to comply with these requirements may cause a suspension of progress payments during the period of noncompliance or may delay final payment. Except as noted in Article 1.05 C.3 above, payment for work directed under any Change Notice shall not be invoiced and will not be paid until execution of the related Change Order. The Engineer

will review the proposed invoice, and subject to making any modifications agreed to by the parties that are needed to make the invoice acceptable, the Engineer will approve the proposed invoice. The Engineer will retain a copy of such approved invoice for reference in preparing the District's payment application package and then provide the Contractor with a complete package in PDF form. Package will contain Payment Application Forms signed by BART Management, the approved invoice, and any additional supporting evidence as required for processing of the payment, and a copy of the form, approved by the Engineer, with the Subcontractor payment information from BART's designated website for electronic submittal of certified payroll records. The Contractor shall submit the complete package to BART's Accounts Payable Department, via E-mail to: ap_supplier@bart.gov. In accordance with General Conditions Article GC9.7.2, the District will pay such invoices within thirty (30) Days following receipt of the above-referenced email submittal to BART Accounts Payable Department.

2. Invoice for Stored Materials: Unless otherwise specified in the Contract Specifications, partial payments for Contractor-furnished materials not yet installed will be made only after such materials have been furnished, inspected and stored for use in the Work, provided they are stored in an area approved by the Engineer. All such material shall be covered by insurance. Said invoice may include the amount and value of such acceptable material as has been furnished, inspected and delivered to the site, and such acceptable material as has been furnished, inspected and stored for use in the Work, provided it is stored within the Continental United States and is segregated and designated for exclusive use of the District.

3. Cost Determination: The cost of invoiced materials shall be determined in accordance with General Conditions Article GC9.3.1.2, Materials. Invoices from suppliers shall be furnished to substantiate the cost.

B. Full Compensation:

1. Payment will be full compensation for furnishing all labor, materials, tools, equipment, transportation, facilities, services, and incidentals, as specified in General Conditions Article GC9.1, Scope of Payment, and for performing all work necessary for completing the construction or installation of the item or work classification.

2. Whenever it is specified or indicated in the Contract Documents that the Contractor is to perform work or furnish materials for which no price is fixed in the Contract, it is understood and agreed that there is included in each lump-sum price bid, or unit price bid, the entire cost of the Work, including all items of work which are incidental to the completion of those portions of the work covered by such lump-sum price bid, or unit price bid, or, if not directly incidental to any specific Bid Item in the Bid Schedule, the cost thereof has been distributed among those Bid Items in the Bid Schedule considered most appropriate by the Contractor.

3. Work which is not clearly delineated in the Contract Documents to be under a particular Bid Item in the Bid Schedule shall be automatically assigned to one of the lump-sum Construction items in the Bid Schedule by the Contractor, so that all items of work, regardless of their characteristics or anonymity, are included in

the Contract Price. Additional compensation will not be made for work items which do not clearly fall under listed Bid Items in the Bid Schedule.

1.07 REJECTED, EXCESS, OR WASTED MATERIALS

Quantities of material wasted or disposed of in a manner not called for under the Contract; rejected loads of material, including material rejected after it has been placed by reasons of the failure of the Contractor to conform to the provisions of the Contract; material not unloaded form the transporting vehicle; material placed outside the lines indicated on the Contract Drawings or established by the Engineer; or material remaining on hand after completion of the Work, will not be paid for, and such quantities shall not be included in the final total quantities. No additional compensation will be permitted for loading, hauling, and disposing of rejected material.

1.08 MEASUREMENT AND PAYMENT

Separate measurement or payment will not be made for work required under this Section. All costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work.

END OF SECTION 01 20 00

SECTION 01 31 19

PROJECT MEETINGS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Pre-construction meeting.

B. Construction Progress meetings.

1.02 RELATED SECTIONS

A. Section 01 81 13, Sustainability Requirements.

B. Section 01 57 00, Temporary Controls.

C. Section 01 35 24, Construction Safety.

D. Section 01 35 14, Operating System Interface.

1.03 MEASUREMENT AND PAYMENT

A. Separate measurement or payment will not be made for work required under this Section. All costs in connection therewith will be considered incidental to the item of work to which they pertain.

1.04 PRE-CONSTRUCTION MEETING

A. A pre-construction meeting will be scheduled by the Engineer which may occur prior to but not more than seven working Days after the effective date of the Notice to Proceed. The purpose of this meeting is to introduce the Engineer's representatives for construction management to their counterparts in the Contractor's organization and to establish lines of communication among these representatives. The Contractor's Project Manager, superintendent, quality representative, safety representative, EEO officer, and Subcontractor representatives, and community relations representatives shall attend. Not less than four working Days before the meeting, the Engineer will distribute a notice of this meeting, along with an agenda of the subjects to be addressed.

B. The Engineer will discuss the following requirements at this meeting:

1. Responsibilities and authorities of the District and the Engineer.

2. Equal Employment Opportunity (EEO), and Office of Civil Rights (OCR) requirements if applicable.

3. Quality assurance, quality control, inspection, and coordination of the Work.

4. Discuss and establish arrangements for safety, first-aid, emergency actions, security, and full-time safety representative as defined in Section 01 35 24, Construction Safety.

5. Discuss Unusual Occurrence Report requirements (eg. photographic documentation).

6. Traffic requirements and permit requirements as applicable to the Work.

7. Sustainability agenda items, as specified in Section 01 81 13, Sustainability Requirements.

8. Procedures for submitting and processing Change Notices, Change Orders, Shop Drawings, product data, and samples.

9. Monthly progress payment cut-off dates.

10. Partial and final payments.

11. Discuss permitting, insurance, and bonding requirements.

12. Discuss equipment and material use and storage by implementation of a Water Pollution Control Plan or Storm Water Pollution Prevention Plan as applicable in Section 01 57 00, Temporary Controls.

13. Discuss Track Allocation process and Site-Specific Work Plans (SSWP), as specified in Section 01 35 14, Operating System Interface.

C. The Contractor shall perform the following at this meeting:

1. Introduce the Contractor’s representatives, and briefly describe each person’s responsibilities.

2. Distribute and discuss the list of major Subcontractors, their areas of responsibility, sequence of critical work, and tentative schedule of construction.

3. Discuss use of office, storage areas, staging areas, construction areas, and temporary easements.

4. Discuss construction safety.

5. Define housekeeping procedures.

6. Discuss construction methods.

7. Discuss quality control/quality assurance.

8. Describe construction sequencing of the entire Contract, general jobsite layout, erosion and sedimentation control plans, haul routes, noise abatement, dust abatement, air and water pollution control, temporary street closings, and street restoration, as applicable.

9. Discuss coordination and notifications required for utility work and services.

10. Discuss sustainability action plans, as specified in Section 01 81 13, Sustainability Requirements.

11. Discuss deliveries and priorities of major equipment.

12. Discuss breakdown of lump sum items.

13. Discuss construction progress schedule.

1.05 CONSTRUCTION PROGRESS MEETINGS

A. The Engineer will schedule construction progress meetings each week and more often as necessary for the competent and timely execution of the Contract. The Contractor's personnel indicated in Article 1.03 shall attend these meetings. Progress meetings shall include representatives of Subcontractors who are or will be performing work during the next week.

B. The Engineer will distribute notices of these meetings before such meeting to the Contractor.

C. The agenda for construction progress meetings will be prepared by the Engineer with input from the Contractor and will include the following:

1. Introduction of new attendees and areas of responsibility.

2. Review of minutes of previous meetings, amendment of minutes if necessary, and acceptance of minutes.

3. Analysis of work accomplished since the previous meeting, offsite fabrication problems, product delivery problems, submitted schedule slippages, problems arising from proposed changes, and other circumstances which might affect progress of the Work. The Contractor shall have an updated Four-Week Work Plan schedule showing all activities started, completed, and ongoing during previous week and such activities scheduled for the next week.

4. Discussion of sequence of work on the critical path, and schedule of construction using the progress schedule. Each activity shall have a current status and forecast completion. The Contractor shall report on all activities which are forecast to be completed beyond the approved schedule date(s) and shall identify means of maintaining the approved schedule.

5. Discussion of work quality observations, problems, and employee work standards.

6. Discussion of coordination of utility work and other work by District and outside parties.

7. Discussion of sustainability agenda items, as specified in Section 01 81 13, Sustainability Requirements.

8. Discussion of changed conditions, time extensions, and other relevant subjects as they affect the progress of the Work.

9. Discussion of corrective measures to maintain construction progress schedule when necessary.

10. Discussion of potential claims and pending disputed issues.

11. Inquiries, requests for information, and Change Notices/Change Orders.

12. Discussion of upcoming month's work.

PART 2 – PRODUCTS

Not Used

PART 3 – EXECUTION

Not Used

END OF SECTION 01 31 19

SECTION 01 32 16

CONSTRUCTION PROGRESS SCHEDULES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Contract Schedule.

B. Baseline Narrative Report.

C. Progress Status Report.

D. Gantt Charts.

E. Four-Week Work Plan.

F. Review, Updates and Revisions.

G. Recovery Schedule.

H. Time Impact Evaluation.

I. Requests for time extensions.

1.02 RELATED SECTIONS

A. Refer to the following sections for requirements:

1. General Conditions Article GC1.3.
2. General Conditions Article GC8.0.
3. Section 01 11 00, Summary of Work.
4. Section 01 33 00, Submittal Procedures.
5. Section 01 33 23, Shop Drawings, Product Data, and Samples.

1.03 MEASUREMENT AND PAYMENT

A. Separate measurement or payment will not be made for work required under this Contract Specifications Section. All costs in connection with the work specified herein will be considered to be included with the related items of work in the Bid Schedule of the Bid Form, or incidental to the Work.

1.04 DEFINITIONS

A. Definitions: The following definitions, in addition to definitions included in General Conditions Article GC1.3, apply to the Contract.

1. Activity: A task, event or other Contract element on a schedule that contributes to completing the Contract. An activity has a description, start date, finish date, duration, and is linked to one or more other activities.

2. Actual Dates: The actual start or finish date of an activity.

3. Bar Chart (Gantt Chart): A graphic display of schedule-related information in which activities or other Contract elements are listed down the left side of the chart, dates are shown across the top, and activity durations are shown as date-placed horizontal bars.

4. Baseline Schedule: The first Critical Path schedule submitted by the Contractor and approved by the Engineer. The baseline schedule includes the scope of Work and show Contract milestones, and deliverables, including the Contractor's scheduled completion date, any float, and the Contract completion date.

5. Contract Completion Date: The contractual date for completion of the Contract, calculated from Notice-to-Proceed and the Contract day duration indicated or revised Contract duration based on any District-approved Change Orders authorizing additional time.

6. Contract Schedule: The baseline schedule as modified by any subsequent, approved schedules including subsequent approved revisions, progress schedules or recovery Schedules. Approved shall mean approval by the Engineer.

7. Critical Path Operations: Refer to General Conditions Article GC1.3, for definition.

8. Critical Path: Refer to General Conditions Article GC1.3, for definition.

9. Critical Path Method (CPM): A network-based planning technique using activity durations and the relationships between activities to mathematically calculate a schedule for the entire Contract.

10. Data Date: The date in the Contract schedule that gives the current status of activities as of this date. Everything occurring on or after the data date is planned.

11. Early Completion Date: A scheduled completion date that is earlier than the Contract completion date.

12. Float: Also called slack. The amount of time that any activity or chain of activities can be delayed before extending the Contract completion date.

13. Lag: A scheduling tool that allows for insertion or removal of time between two linked activities in a manner that impacts the successor activity's forecasted start or completion dates. Negative lag occurs where the start time for an activity overlaps with and is earlier than the finish time of the preceding activity. Positive lag occurs where Day(s) for which no work is scheduled elapse between the start time of one activity and the finish time of the preceding activity.

14. Milestone: A marker in a network which is typically used to mark a point in time or denote the beginning or end of a sequence of activities in the Contract schedule. A milestone has zero duration, but will otherwise function in the network as if it were an activity. Milestones shall include but are not limited to any activities described as milestones in Contract Specifications Section 01 11 00, Summary of Work.

15. Narrative Report: A document submitted with each schedule that discusses, in narrative form, topics related to Contract progress and scheduling. The narrative report shall identify any changes made in the attached schedule submittal and the reasons for the change.

16. Out-of-Sequence Activity: Any activity that actually starts in a sequence other than that shown in the Contract schedule.

17. Progress Schedule: An updated Contract Schedule submitted by the Contractor on a monthly basis subject to approval by the Engineer that incorporates monthly as-built progress and any planned changes.

18. Progress Status Report: The narrative report submitted with a progress schedule that also summarizes activities and work completed during the past month.

19. Recovery Schedule: A revision to the Contract schedule prepared by the Contractor for the Engineer's review and approval to show how delays can be recovered so that the Contract completion date or any specified milestone is met.

20. Revision: A change to the Contract schedule either initiated by the Contractor or requested by the Engineer that modifies logic; adds or deletes activities; or alters activities, sequences, or durations.

21. Scheduled Completion Date: The planned date of completion of the Work shown on the Contract schedule.

22. Site Specific Work Plan ("SSWP"): A detailed work plan for items within or near the BART Operating Envelope, substations, or gap breakers. The SSWP is prepared by the Contractor and approved by the District.

23. Time Impact Evaluation ("TIE"): A schedule and narrative report developed specifically to demonstrate what effect a proposed change or delay has on the Contract completion date or for a milestone for which liquidated damage are specified.

24. PERT: Program Evaluation and Review Technique. PERT activity duration is defined by the following formula:

$$\text{Activity duration} = \frac{\text{Optimistic duration} + \text{Pessimistic duration} + (4 * \text{Most likely duration})}{6}$$

1.05 SUBMITTALS

A. Comply with submittal requirements herein and in Section 01 33 00, Submittal Procedures.

B. Qualifications of Contractor's Contract scheduler: submitted seven (7) Days after NTP.

C. Contract schedule shall be submitted as follows:

1. Baseline schedule and narrative report: submitted within thirty (30) Days after NTP.

2. Progress schedule and progress status report: submitted monthly in accordance with General Conditions Article GC8.0 or as often as deemed necessary by Engineer. Submit updated progress schedule and progress status report by at least five (5) Days before submitting a payment invoice. Progress schedule submittals shall show an accurate history of the submittals and resubmittals and the District review period for each submittal and resubmittal. Actual submittal numbers shall be included in the submittal activity name.

D. Contract schedule submittal shall include the following:

1. A USB drive containing the schedule file in the native file format (e.g. Primavera).

2. One soft copy in pdf file format and three hard copies. Each copy shall include:

a. The time-scaled bar chart with logic lines formatted and printed on sheet no smaller than 22 inches wide by 34 inches long and no longer than 34 inches wide by 44 inches long.

b. A time-scaled logic diagram.

c. An activity report in tabular form showing activity ID, description, duration, float, early start, early finish, late start, late finish, predecessors, successors, constraints, percent complete, and remaining duration. Report shall be consistent with the scheduling file.

d. The baseline narrative report or progress status report.

1.06 QUALITY ASSURANCE

A. The Contractor's Contract scheduler shall have a minimum of five (5) years of scheduling experience on construction projects of the size and scope similar to or larger than the Contract. Within seven (7) Days of the issuance of NTP, the Contractor shall submit for the Engineer's approval the resume of its proposed Contract scheduler. If the approved Contract scheduler stops working under the Contract or assumes responsibilities other than scheduling, the Contractor shall immediately notify the Engineer and submit, for the Engineer's approval, the resume of the intended replacement Contract scheduler.

1.07 CONTRACT SCHEDULE

A. General

1. The Contract Schedule and any subsequent modifications shall represent a logical and practical plan to complete the Work by the Contract completion date and shall convey the Contractor's intent in the manner of prosecution and progress of the Work.

2. The scheduling and execution of construction in accordance with the Contract Documents shall be the responsibility of the Contractor. The Contractor shall involve and coordinate with Subcontractors and Suppliers in the development and updating of any Contract Schedule that may affect a Subcontractor or Supplier.

3. Contract Schedule submitted by the Contractor shall be understood to be the Contractor's representation that the Contract schedule meets the requirements of the Contract Documents and that the Work shall be executed in the sequence and duration indicated in the Contract schedule.

4. Contract Schedule prepared by the Contractor shall meet the requirements for access, sequencing, construction staging, delivery of District-furnished materials, Contract constraints, Contract milestone and completion dates as specified in the Contract Documents.

5. The Contract Schedule shall be the basis for evaluating Contract progress and time extension requests. Responsibility for developing the Contract schedules and monitoring actual progress rests with the Contractor.

6. Inaccuracy in the Contract schedule or failure of the schedule to include any element of the Work shall not relieve the Contractor from responsibility for accomplishing the Work in accordance with the Contract requirements. It shall be the Contractor's responsibility to prepare and submit accurate and realistic Contract schedules for the duration of the Contract. The Engineer will rely on the Contract schedule for planning purposes. The Contractor shall be responsible for any inaccurate information or flaws in logic shown in the Contract schedule that may lead to inaccurate time extension analyses or conclusions. Engineer's review and approval of Contract schedule does not void Contractor's responsibility.

B. Format

1. Contract schedule shall be computer produced in the Critical Path Method (CPM) format, utilizing project scheduling software such as Primavera and Microsoft Project or other equivalent software as approved by the Engineer.

2. For base Contract value greater than $85M, the PERT activity duration for each activity shall be used for duration of task. On qualifying PERT projects, a 95 percent confidence schedule shall be submitted with the baseline schedule and maintained throughout the Contract. Progress schedules shall be submitted using this technique. Contractor shall provide the three durations for each activity to Engineer upon request. PERT durations shall be rounded up to the nearest full day.

3. Contract schedule shall show Contract tasks, duration of tasks, percent complete, progress bars, milestones, start and finish dates, and other breakdowns as required by the Engineer.

4. Activities shall be identified by the work area in which the activity occurs. The work area of each activity shall be identified by work area code.

5. Each activity shall be coded by one responsible party.

6. Contract schedules shall clearly show the sequence of activities and shall list specifically the following activities:

   a. Milestone completion dates. Phasing and staging shall be prominently identified.

   b. Submittals and the Engineer’s review of submittals.

   c. Acquisition of permits.

   d. Major procurement activities and all long lead time items. Long lead items shall mean any item that takes over sixty (60) Days for delivery.

   e. Work to be performed by other contractors or agencies.

7. Activities in the Contract schedule shall include sufficient detail to identify the work that is to be accomplished. Such detail shall include the following:

   a. Clear, well defined, and unambiguous activity descriptions including what signifies the start and finish of the activity.

   b. Sufficient activities to clearly show the sequence and interdependencies of the Work. An activity or group of activities shall correspond directly with Bid Item breakdowns or the breakdown of lump sum Bid Items. Add additional activities requested by the Engineer.

   c. Activity durations shall be expressed in whole Days. Work that is to be performed by Subcontractors shall be clearly defined. The duration of field activities shall not exceed ten (10) working days.

d. Activities, with the exception of the first and last activities, shall have a minimum of one predecessor and a minimum of one successor.

e. Dependencies or relationships between activities shall be shown.

f. Punchlist tasks and time for testing shall be included prior to Substantial Completion.

g. The interface with the work of other contractors and agencies such as, but not limited to, utility companies, shall be indicated.

h. A list of anticipated non-work weather days and holidays. Exclude weekends from this list.

i. Include activities for the District's review of any SSWP, submittals, access notice, and maintenance support schedule (MSS).

j. The activity calendars shall show the working hours for each calendar.

k. Clearly show the non-revenue hours work activities.

l. Incorporate and log the anticipated and actual non-work weather days per General Conditions Article GC8.5.1.4.

8. Contractor shall keep multiple Critical Paths and near Critical Paths to a minimum. A total of not more than 50 percent of the baseline schedule activities shall be critical or near critical unless authorized by the Engineer.

9. Float suppression techniques, such as preferential sequencing (e.g. crew movement, equipment use, and form reuse), extended duration, imposed dates, scheduling of work not required for the Contract, shall not be used. The use of constraint dates shall be minimized, and shall be approved by the Engineer if used. Mandatory constraints are not allowed.

C. Contract schedule submittal showing that Work is completed in less than the completion time specified in the Contract may be found to be impractical by the Engineer.

D. Contract schedule showing that Work is completed prior to the Contract completion date and that is found to be practical by the Engineer shall be considered to have float. Floats shall be a resource available to both parties as the need for the use of the float arises.

E. Any Contract Schedule submittal showing a completion date earlier than the Contract completion date shall show the time between the scheduled completion date and the contract completion date as float.

F. The term "delay" shall mean failure to meet the Contract completion date or any dates specified in Contract Specifications Section 01 11 00, Article 1.10, Contract Liquidated Damages. Failure to meet the scheduled completion date shall not entitle the Contractor to compensable delay damages, if the Contract completion date is met. The District shall not be responsible for any damages related to the use of float to a failure to meet an early completion date, including extended overhead costs or early completion delay damages.

G. The use of negative lag is not allowed. Positive lag may be allowed subject to approval by the Engineer.

H. Contract schedule found to be impractical by the Engineer for insufficient detail or for any other reason shall be revised by the Contractor and resubmitted for review and approval.

1.08 BASELINE NARRATIVE REPORT

A. Baseline narrative report shall describe the basis, assumptions, planned sequences of work operations, production rates, equipment, resources, and constraints used to develop the baseline schedule. Upon request by the Engineer, provide a written statement signed by Subcontractors showing acceptance of the baseline schedule and any portion of said schedule affect the Subcontractor.

1.09 PROGRESS STATUS REPORT

A. Progress status report shall include the following:

1. Identification of unusual restrictions or conditions occurring or discovered during the update period regarding labor, equipment, or material. Unusual restrictions or conditions may include multiple shifts, six-day work weeks, and specified overtime or work at times other than regular Days or hours.

2. Description of the current Critical Path and the reasons for deviation from the last update.

3. Current and anticipated delays including cause of delay; impact of delay on other activities, milestones, and other completion dates; and corrective action and schedule adjustments to correct the delay.

4. Any proposed or approved corrective action and schedule adjustments to correct the delays, if any.

5. Work completed during the update period. List and detailed explanation of schedule logic changes from last schedule submittal.

6. Schedule logic changes include name changes; added or deleted activities; and added or deleted links, lags, duration changes and constraints.

1.10 GANTT CHARTS

A. The time-scaled Gantt charts shall conform to the following:

1. Show a continuous flow of information from left to right.

2. Be based on early start and early finish dates of activities.

3. Clearly show Critical Paths using graphical presentation.

4. Be prepared on D-size sheets (24 inches by 34 inches).

5. Include a title block and a timeline on each page.

1.11 FOUR-WEEK WORK PLAN

A. A schedule in calendar time-scaled bar chart format depicting the Contractor's intended work activities for the upcoming four-week period shall be submitted on a weekly basis and shall be due on the first working day of each week. Each activity of one (1) Day or more in duration shall be indicated. This Four-Week Work Plan shall also show the previous week's activities, leading into the upcoming four-week period.

B. The first Four-Week Work Plan shall be submitted one week ahead of any physical Work at the Jobsite.

C. The Four-Week Work Plan shall be a detailed break-down and update of activities of the Contract schedule. Every task in the Four-Week Work Plan shall show the corresponding activity ID number in the latest submitted Contract schedule as well as the Subcontractor's or Supplier's name performing the work.

D. The Four-Week Work Plan shall identify activities to be performed outside of the normal work shift for the Engineer to schedule inspection resources

E. Any deviations, such as sequences of work, timing, and durations of activities from the approved Contract schedule, shall be noted and explained in writing.

F. The Engineer's comments on the Four-Week Work Plan with which the Contractor disagrees shall be resolved in a meeting held for that purpose, if necessary.

G. The Four-Week Work Plan shall be submitted on sheets not less than 8-1/2 inches by 11 inches, or as approved by the Engineer.

1.12 REVIEW, UPDATES, AND REVISIONS

A. The Engineer will review and return the following Contractor's Contract Schedule submittals with written comments according to the schedule below. Review periods shall begin to run from the date of BART's receipt of a complete submittal.

Baseline Schedule:	Twenty (20) Days
Progress Schedule, Revisions and Recovery Schedule:	Fourteen (14) Days

B. The Contractor shall make all corrections to a Contract Schedule submittal as requested by the Engineer and resubmit the schedule for approval within seven (7) Days of notification by the Engineer. If the Contractor does not agree with the Engineer's comments, the Contractor shall provide written notice of disagreement within five (5) Days from the receipt of the Engineer's comments. In case of disagreement on schedule logic changes, parties shall meet within five (5) Days to discuss proposed changes. The Engineer's direction with respect to logic change shall be noted in all the subsequent progress status reports if no agreement is reached. Failure to agree to schedule corrections diminishes the reliability of the Progress Schedules and any subsequent TIE that relies on the disagreed logic and dates.

C. Resubmittals shall conform to the same requirements as original submittals.

D. Allow seven (7) Days for Engineer's review of Contract schedule resubmittals.

E. The Engineer reserves the right to withhold progress payments or a portion thereof until a current Contract schedule has been approved by the District.

F. The numbering of the activities in the progress or recovery schedules shall be the same as in the accepted baseline schedule. Numbers of deleted activities shall not be used on any subsequent progress or recovery schedules. New numbers shall be used for new activities.

G. The first of each type of schedule and the first monthly progress schedule and report submitted by the Contractor will be reviewed for format, as well as content. The Engineer may request format changes. Once the format has been approved, all subsequent schedules, progress schedules, and progress status reports submitted by the Contractor shall be submitted in the approved format.

1.13 RECOVERY SCHEDULE

A. If, according to the progress schedule, the Contractor is thirty (30) or more Days behind the Contract completion date or for a milestone for which liquidated damages are specified, including all approved time extensions, the Contractor shall submit a recovery schedule.

B. Within seven (7) Days after request by the Engineer, the Contractor shall submit a proposed schedule, showing the Contractor's proposed revisions to recover the lost time. As part of this submittal, the Contractor shall provide a written narrative report that shall discuss each proposed revision made to recover the lost time.

C. The narrative report shall explain the Contractor's proposed methodology, basis, and assumptions made in the recovery of lost time. If the revisions include sequence changes, the Contractor shall provide a schedule diagram comparing the original sequence to the revised sequence of Work. The recovery schedule shall be prepared as a modification to the current progress schedule that incorporates proposed revisions to recover the lost time.

D. The proposed changes in a recovery schedule shall not be incorporated into any updated progress schedule until they have been approved by the Engineer. Once proposed revisions are approved by an Engineer, the Contractor shall include the approved revisions into the next monthly progress schedule submittal.

E. Upon request by the Engineer, the Contractor shall provide written statements signed by affected Subcontractors showing approval of the recovery schedule and portions of the schedule affecting the Subcontractor.

1.14 TIME IMPACT EVALUATION

A. When the Contractor becomes aware of circumstances including Change Notices, Force Account directives, or other District-caused delays, the Contractor shall prepare and submit a time impact evaluation ("TIE") within fifteen (15) Days of the event, which includes both a written narrative and a schedule diagram depicting how the changed work affects other schedule activities. The Contractor's failure to provide the TIE within the time specified shall be considered as Contract non-compliance pertaining to the Contractor's attempt to file any claims or time extension requests associated with the pertinent TIE issue.

B. TIE shall be based on an approved baseline or progress schedule that has a data date closest to and before the occurrence of the event. The TIE shall incorporate District's previous unaddressed or pending schedule review comments. The TIE shall show actual logic for the completed portion of the schedule as performed and verified in the field. If the approved baseline or progress schedule used for TIE does not show accurate as-built or remaining incomplete activity logic and duration, then the TIE schedule shall be revised to show the most accurate logic and sequence.

C. The schedule diagram shall show how the Contractor proposes to incorporate the changed work in the Contract schedule and how it impacts the Contract completion milestones or any interim milestone with liquidated damages.

D. The diagram shall be tied to the main sequence of schedule activities to enable the Engineer to evaluate the impact of the changed work to the Critical Path. Until approved by the Engineer, the TIE activities shall not be incorporated into monthly progress schedule submittals.

E. If the parties cannot agree on the time extension as depicted in the TIE, the Contractor shall submit a revised TIE at the conclusion of the delay period, incorporating as-built dates and logic in the revised TIE. The revised TIE shall incorporate the latest schedule logic revisions that were made after the submittal of the initial TIE and the impact of any and all concurrent delays, consistent with requirements of General Conditions Article GC8.0 and other relevant sections.

1.15 REQUESTS FOR TIME EXTENSIONS

A. If the Contractor requests an extension of time for the Contract completion date or for a milestone for which liquidated damages are specified, the Contractor shall furnish necessary justification for such extension so that the Engineer can determine whether or not the Contractor is entitled to an extension of time under the provisions of the Contract. Submission of proof based on revised activities logic, and duration, is obligatory to any approvals. The cost of such justification or subsequent schedule revisions shall be borne solely by the Contractor.

1. The time extension evaluation shall fully comply with requirements of General Conditions Article GC8.0 and other relevant sections and clearly display that the Contractor has used, in full, the entire float available for the Work involved in its request.

2. The Engineer's determination as to the total number of Days for extension of the Contract completion date will be based upon the Contract schedule, General Conditions Article GC8.0 and other relevant information. Actual delays in activities that, according to the schedule, do not affect the Contract completion date as shown by the Critical Path, shall not be the basis for a change to the Contract completion date.

3. After receipt of such justification and supporting evidence, the Engineer will review the facts and advise the Contractor of the Engineer's decision. Any change to a milestone, for which liquidated damages are specified, or to the Contract completion date will be made by a Contract Change Order.

4. In addition to TIE, any Contractor's request for compensation for schedule delays shall include a but-for analysis that incorporates a complete concurrent delay analysis as required by General Conditions Article GC8.0. Since the TIE is based on progress schedules that may not depict the correct dates or logics of incomplete activities, such but-for analysis requires analysis of as-built information at a later date so that the impact of the actual as-built dates and logic ties are used.

PART 2 – PRODUCTS

Not Used

PART 3 – EXECUTION

Not Used

END OF SECTION 01 32 16

SECTION 01 32 33

PHOTOGRAPHIC DOCUMENTATION

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Stages of construction.

B. Quality and quantity of photographs.

C. Identification of photographs.

D. Video recordings.

E. Disputes, and potential claims.

F. Safety violations, accidents, unusual occurrences, near misses.

1.02 MEASUREMENT AND PAYMENT

A. Separate measurement or payment will not be made for work required under this Section. All costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work.

1.03 STAGES OF CONSTRUCTION

A. The Contractor shall take photographs at all construction milestones and at each of the following stages of construction:

1. Before commencement of clearing and demolition;

2. Upon completion of clearing and demolition;

3. Monthly during performance of the Work; and

4. Upon completion of the Work.

5. Anytime a problem arises that may result in a Notice of Potential Claim and the problem can be illustrated by photographs.

B. At least three different views or vantage points of each milestone and stage of construction shall be furnished. The quantity of photographs required for submission will be determined by the Engineer. Location of views shall be as approved by the Engineer.

1.04 QUALITY AND QUANTITY OF PHOTOGRAPHS

A. All photographs shall be digital photographs stored on CD-ROM, DVD or approved other media. Digital photographs shall be in pdf, jpg or png format with the following requirements:

1. Minimum resolution: 1024 x 768 pixels.

2. Colors: 24 Bits per Pixel.

3. Maximum File size of 3MB.

B. Digital photographs provided shall use the following file naming convention:

PYYMMDDLOCATIONSEQ.EXT

P =	Photograph
YYMMDD =	Date in Year, Month, Day format
LOCATION =	(8 Characters maximum) Location taken, either by BART 3-character alpha numeric + 5, or Milepost by line designation. (e.g. M90, C40-west, A1MP32-1, etc.)
SEQ =	Sequential number from 001 to 999.
EXT =	File extension (e.g. pdf, jpg, or png).

C. CD-ROM or DVD disc shall be labeled to include the Contract number and the date the photographs were taken.

1.05 IDENTIFICATION OF PHOTOGRAPHS

A. The following information shall be furnished for each digital photograph in a manner approved by the Engineer.

1. Title of Contract and Contract Number;

2. Identification of subject shown;

3. Station point of camera and direction of view;

4. Camera or Portable Electronic Device (PED) shall be capable of printing time and date stamp on photos taken. No PEDs shall be used for taking photos when fouling the tackway.

1.06 VIDEO RECORDINGS

A. The Contractor shall provide video recordings to supplement contract photographs of certain construction milestones and events as indicated herein:

1. Start of construction including clearing and demolition operations, as applicable;

2. Highlights of all formal inspections; and

3. Highlights of the final inspection and acceptance by the District.

4. As requested by the Engineer

B. Video recordings shall be standard definition DVD - Video format and stored on a DVD optical disc.

C. Video recordings shall include a complete, clearly spoken narration of the events being photographed. Also, video recordings shall include an unobtrusive time and date indicator on the film, accurately depicting the time and date when the photography was performed.

D. The DVD disc shall be labeled with the same identifying information specified above for photographs. In addition, the narration of each recording shall lead off with this same identifying information.

E. Individual digital video files shall use the file naming convention indicated in 1.04B, however the filename shall be modified such that the first character shall be “V” for video instead of “P”.

1.07 DISPUTES AND POTENTIAL CLAIMS:

A. In the event a problem arises or dispute occurs which may result in a Notice of Potential Claim under Article GC9.4.1 of the General Conditions and the problem or dispute can be illustrated by photographs and video recordings, the Contractor shall provide such photographs and video files.

PART 2 – PRODUCTS

Not Used

PART 3 – EXECUTION

Not Used

END OF SECTION 01 32 33

SECTION 01 33 00

SUBMITTAL PROCEDURES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. List of material sources.

B. Submittal requirements.

1.02 RELATED SECTIONS

A. Project progress schedules and status reports are specified in Section 01 32 16, Construction Progress Schedules.

B. General requirements and procedures for preparing and submitting Shop Drawings, product data, and samples are specified in Section 01 33 23, Shop Drawings, Product Data, and Samples.

C. Submittals related to the Contractor's quality program are specified in Section 01 45 00, Quality Control.

D. Submittals required to complete the Contract closeout are specified in Section 01 77 00, Closeout Procedures.

E. Preparation and submission of project record documents are specified in Section 01 78 39, Project Record Documents.

F. Preparation and submission of equipment and systems operation and maintenance manuals are specified in Section 01 78 23, Operation and Maintenance Data.

G. Preparation and submission of Training Program Deliverables such as Training Program Plan, Instructor Guides, and Student Training Manuals are specified in Section 01 79 00, Demonstration and Training. Sustainability Information submittal requirements are specified in Section 01 81 13, Sustainability Requirements and are referenced in the Technical Specifications as applicable.

1.03 MEASUREMENT AND PAYMENT

A. Separate measurement or payment will not be made for work required under this Section. All costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form or incidental to the Work.

1.04 LIST OF MATERIALS SOURCES

A. The Contractor shall submit to the Engineer a list of the Contractor's sources of materials. The list shall be submitted in sufficient time to permit proper inspections

and testing of materials to be furnished from such listed sources in advance of their use.

1.05 SUBMITTAL REQUIREMENTS

A. Submittals for Approval: Specific submittals shall be understood to be submitted to the Engineer for approval, except as otherwise specified in Article 1.07B, herein, or specified to be submitted to others such as a designated approval authority for its approval.

B. Schedule of Submittals:

1. Within 10 Days after the effective date of Notice to Proceed, the Contractor shall submit a completed submittal schedule and list of products for all items requiring the Engineer's review and approval, as follows:

   a. Submittals, including description of the item and name of manufacturer, trade name and model number.

   b. Contract Specifications reference.

   c. Intended submission/resubmission date(s).

   d. Order release date.

   e. Lead time to delivery/anticipated delivery date(s).

   f. Highlight any items that require expedited review to meet the Contract schedule.

   g. Not more than 30 Days after the effective date of Notice to Proceed, the Contractor shall provide to the Engineer an updated schedule of submittals that includes cost and sustainability information. See Contract Specifications Section 01 81 13, Sustainability Requirements, for Contract Materials Cost Schedule submittal requirements.

2. These schedules shall be presented in a form acceptable to the Engineer in both electronic and hard copy versions and shall be updated and sent to the Engineer on a monthly basis. Identify all submittals that are required by the Contract Documents and determine the date on which each submittal will be submitted in conformance with the schedules specified in Section 01 32 16, Construction Progress Schedules.

C. Professional Seal Required: Submittals involving engineering design services, when required by the Contract Documents or by governing codes and regulations, such as shoring and underpinning, excavation support structures, falsework for concrete, fire protection system design, and load and design calculations, shall be sealed and

signed in blue ink by a professional engineer, currently registered in the State of California, for the discipline involved.

D. Review Period:

1. Prepare submittals sufficiently in advance so that approval may be given before commencement of related work.

2. Unless otherwise specified, allow 30 Days after receipt by the Engineer for review of each submittal, including 30 Days for each resubmittal.

3. The Contractor shall be responsible for determining whether or not certain governmental entities and utility districts require longer review periods. When longer review periods are required, the Contractor shall schedule the Work accordingly, so that the Work and project progress schedules are not adversely impacted.

E. Submittal Delivery: Ship submittals prepaid or deliver by hand directly to the Engineer.

F. Transmittal Form: Accompany submittals with a District-furnished transmittal form in duplicate containing the following information:

1. The Contractor's name, address, and telephone number;

2. Submittal number and date;

3. Contract title and number;

4. Supplier's, manufacturer's, or Subcontractor's name, address, and telephone number; and

5. Subject identification including Contract Drawing and Specifications reference.

G. Changes in Approved Submittals: Changes in approved submittals will not be allowed unless those approved submittals with changes have been resubmitted and approved, in the same manner as the original submittal.

H. Supplemental Submittals: Supplemental submittals initiated by the Contractor for consideration of corrective procedures shall contain sufficient data for review. Make supplemental submittals in the same manner as initial submittals.

1.06 CONTRACTOR'S RESPONSIBILITIES

A. Contractor's Review and Approval:

1. Each submittal shall be reviewed, stamped, and signed as reviewed and approved by the Contractor prior to submission. The Contractor's approval shall indicate review and approval with respect to the following responsibilities:

2. The Contractor shall be responsible for:

a. The correctness of the drawings, for shop fits and field connections, and for the results obtained by the use of such drawings.

b. Verification of catalog numbers, and similar data.

c. Determination and verification of field measurements and field construction criteria.

d. Checking and coordinating information in the submittal with requirements of the Work and of the Contract Documents.

e. Determination of accuracy and completeness of dimensions and quantities.

f. Confirmation and coordination of dimensions and field conditions at the site.

g. Safety precautions.

h. Errors or omissions on submittals.

i. Coordination and performance of work of all trades.

j. Identification of deviation(s) from Contract requirements.

k. Sustainability attributes of products, including any required manufacturer's certifications, must be included in the product data submittal.

3. The Contractor shall coordinate each submittal with the requirements of the Work, placing particular emphasis upon assuring that each submittal of one trade is compatible with other submittals of related work. Ensure submittal is complete with all relevant data required for review.

4. The Contractor shall stamp, initial or sign the submittal, certifying:

   a. Dimensional compatibility of the product with the space in which it is intended to be used.

   b. Review of submittals for compliance with Contract requirements.

5. Do not start work for that requires approval by the Engineer until submittals have been returned to the Contractor with official indication that approval has been granted by the Engineer.

6. If a submittal is designated to be submitted to a designated approval authority for approval, the Contractor shall submit a copy of the Contractor's submittal to that authority to the Engineer for information. Upon approval by the designated approval authority, the approved submittal shall be submitted for the Engineer's information.

7. Approval of drawings and associated calculations by the Engineer shall not relieve the Contractor from the responsibility for errors or omissions in the drawings and associated calculations, or from deviations from the Contract Documents, unless submittals containing such deviations were submitted to the Engineer and the deviations were specifically called to the attention of the Engineer in the letter of transmittal and within the submittal, and approved specifically by the Engineer as a Contract change.

8. Approval of the Contractor's submittal by the Engineer shall not relieve the Contractor of any responsibility, including responsibility for accuracy and agreement of dimensions and details.

B. Submittal Quantities: Refer to Contract Specifications Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal quantities.

C. Review by the Engineer**:** One marked up reproducible set of drawings, one copy of product data, and one sample will be returned to the Contractor.

D. Distribution of Submittals after Review: Distribute prints or copies of approved submittals, bearing the Engineer's or designated approval authority's stamp and signature, to the Contractor's field office and the Engineer's field office; to affected and concerned Subcontractors, Suppliers, and fabricators; and to affected and concerned members of the Contractor's workforce.

1.07 ENGINEER'S REVIEW

A. Submittals will be reviewed for conformance with requirements of the Contract Documents. Review of a separate item will not constitute review of an assembly in which the item functions. Nether review nor approval shall relieve the Contractor from Contractor's responsibility for accuracy of submittals, for conformity of submittals to requirements of Contract Documents, for compatibility of described product with other provided products and the rest of the system, or for prosecution and completion of the Contract in accordance with the Contract Documents.

B. Submittals shall be understood as being made for approval, unless otherwise specified, for example, as being made for information, record, or review. The Engineer will indicate its reviews of submittals and the action taken (approvals and non-approvals) by means of its review stamp. The review stamp will be affixed by the Engineer, the action block will be marked, and the stamp will be signed in blue ink and dated.

1. Approval of the submittal by the Engineer does not relieve the responsibilities of the professional engineer who originally signed and sealed the submittal or the responsibilities of the Contractor to meet the Contract requirements.

C. The review-stamp action-block marks will have the following meanings:

1. The mark APPROVED is an acceptance, and means that the submittal appears to conform to the respective requirements of the Contract Documents; that fabrication, assembly, manufacture, installation, application, and erection of the illustrated and described product may proceed; and that the submittal need not be resubmitted.

2. The mark APPROVED AS NOTED - RESUBMISSION NOT REQUIRED is an acceptance, and means that the submittal appears to conform to the respective requirements of the Contract Documents upon incorporation of the reviewer's corrections, and that fabrication, assembly, manufacture, installation, application, and erection of the illustrated and described product may proceed. Submittals so marked need not be resubmitted unless the Contractor challenges the reviewer's

exception within seven Days. All noted changes shall be reflected in the Record (as-built) Drawings and other Record Documents by the Contractor.

3. The mark LIMITED APPROVAL – RESUBMISSION REQUIRED is an approval except for the work impacted by the notes and comments, and means that the submittals require corrections to conform to the respective requirements of the Contract Documents. Fabrication, assembly, manufacture, installation, application, and erection of the illustrated and described product may proceed at the Contract's risk only for the elements of work not impacted by and changes required to incorporate the reviewer's corrections. The noted work cannot proceed until verification by the Engineer that the review's corrections have been properly incorporated in the submittal.

4. The mark NOT APPROVED – RESUBMISSION REQUIRED is a disapproval, and means that the submittal requires corrections to conform to the respective requirements of the Contract Documents, and that fabrication, assembly, manufacture, installation, application, and erection of the illustrated and described product may not proceed until incorporation of the reviewer's corrections and verification by the Engineer that the reviewer's corrections have been properly incorporated in the submittal.

5. The mark REJECTED – RESUBMISSION REQUIRED is a disapproval, and means that the submittal is deficient to the degree that the reviewer cannot correct the submittal with a reasonable degree of effort, has not made a thorough review of the submittal, and that the submittal needs revision and is to be corrected and resubmitted.

6. The mark NOT REVIEWED is acknowledgement of receipt and means that the submittal is for information and record purposes only.

D. Review stamps or other approval methods of the various designated approval authorities may not be the same as those of the District. The Contractor shall work with the various designated approval authorities and shall obtain approvals in the clearest and most straightforward manner possible.

PART 2 – PRODUCTS

Not Used

PART 3 – EXECUTION

Not Used

END OF SECTION 01 33 00

SECTION 01 33 23

SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Submittals.

B. Shop drawings.

C. List of materials sources.

D. Other submittals.

E. Product data.

F. Samples.

1.02 RELATED SECTIONS

A. Section 01 33 00, Submittal Procedures.

B. Section 01 81 13, Sustainability Requirements.

C. Section 01 78 39, Project Record Documents.

1.03 REFERENCES

A. ASME Y14.1, Decimal Inch Drawing Sheet Size and Format

B. Institute of Electrical and Electronic Engineers (IEEE)

C. National Electric Manufacturer's Association (NEMA)

D. American Society of Mechanical Engineers (ASME)

1.04 MEASUREMENT AND PAYMENT

A. Separate measurement or payment will not be made for work required under this Section. All costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work.

1.05 DEFINITIONS

A. Drawings: The term "Shop Drawings," as used herein, includes fabrication, erection and installation, application, layout, and setting drawings, lists or schedules of materials and equipment, manufacturer's standard drawings, wiring and control

diagrams, all other drawings as may be required to show that the materials, equipment, and systems, and the positions thereof, comply with Contract requirements.

B. Product Data: The term “product data,” as used herein, includes manufacturer-prepared descriptive literature, catalog sheets, brochures, performance data, test data, printed diagrams, schedules, illustrations, and other information furnished by the Contractor or the various product and materials suppliers to illustrate and describe a product, material, system, or assembly for some portion of the Work.

C. Samples: The term “samples,” as used herein, are physical examples which illustrate materials, equipment, colors, textures, finishes, functions, configuration, and work quality, and establish the standards of quality and utility by which the Work will be judged for acceptance.

1.06 SUBMITTALS

A. Refer to Section 01 33 00, Submittal Procedures, for submittal procedures.

B. Refer to Section 01 81 13, Sustainability Requirements for Sustainability Information requirements to be included in product data.

C. Quantities:

1. Three full size bond prints of each drawing.

2. Three copies of manufacturers’ standard schematic drawings.

3. Three copies of Contractor’s or manufacturers’ calculations, and three copies of manufacturers’ standard data.

4. Three copies of manufacturers’ printed installation, assembly, erection, application, and placement instructions.

5. Two of each sample item specified in the various Specification Sections, unless otherwise specified.

6. Three copies of inspection reports, test reports, and certificates of compliance.

7. Where submittals are submitted to the Engineer for information or record purposes, submit two copies.

8. Where permits and licenses and other such documents are obtained in the District’s name, submit the original and one copy.

1.07 SHOP DRAWINGS

A. Drawings shall be legible and prepared in accordance with ASME Y14.1, Decimal Inch Drawing Sheet Size and Format, and the following requirements:

1. Drawings shall be limited to the following standard sizes in inches: Maximum size shall be 22 inches by 34 inches.

Name	WIDTH (Vertical)	LENGTH (Horizontal)
ANSI A	8 1/2 inches (215.9mm)	11.0 inches (279.4mm)
ANSI B	11.0 inches (279.4mm)	17.0 inches (431.8mm)
ANSI C	17.0 inches (431.8mm)	22.0 inches (558.8mm)
ANSI D	22.0 inches (558.8mm)	34.0 inches (863.6mm) (Maximum)

2. Each drawing shall have the following information in the title block.

   a. Drawing number, date, title, revision number, and sheet number

   b. Contract number, Contract sheet number, Contract page number.

   c. Contractor's name.

   d. Subcontractor/manufacturer name (if applicable)

   e. Name of installation location.

3. Each drawing shall use symbols from one standard reference source. The Contractor shall furnish a complete symbol list that includes non-standard symbols used on the drawing. Symbols used shall conform to the list of standard references as listed below:

   a. Institute of Electrical and Electronic Engineers (IEEE).

   b. National Electric Manufacturer's Association (NEMA).

   c. American Society of Mechanical Engineers (ASME).

4. Each drawing shall include details necessary for the procurement, installation, maintenance, and repair of all components or facilities equipment provided. Change Order notices that are attached to drawings shall not constitute revised drawings. Each drawing shall include all changes and be upgraded to reflect the latest configuration.

B. Drawings shall be submitted in accordance with the following requirements:

1. The first drawings submitted by the Contractor will be reviewed for conformance to the requirements herein. Once approval is given, the Contractor shall use this approved drawing as the standard, and prepare subsequent drawings to a quality equal to or better than the approved standard.

2. Each drawing prepared and submitted for review shall have in the lower right hand corner, just above the title block, a five-inch square blank space in which the Engineer may indicate the action taken.

3. All final approved drawings and catalog cuts shall be submitted to the Engineer upon completion of the Work as specified in Section 01 78 39, Project Record Documents.

C. When specified, shop drawings shall be prepared and submitted electronically. Such drawings shall be created using AutoCAD in accordance with the District's Contract Drawing CADD Requirements (part of the BART Facilities Standards, Appendices, District Technical Manuals). Shop drawings to be prepared and submitted electronically include shop drawings which will be utilized as illustrations and drawings in Operation and Maintenance Manuals.

1. The initial submittal of such shop drawings shall include electronic copies for review of their conformance with applicable drafting standards. The Engineer will make the Contract Drawing CADD Requirements available upon request.

1.08 OTHER SUBMITTALS

A. Other submittals shall be furnished upon request for the Engineer's approval to verify compliance of all equipment and materials with the Contract Documents. These submittals shall include in addition to drawings: catalog cuts, certifications of compliance, or any other substantiating information or samples of material items as necessary.

1.09 PRODUCT DATA

A. The Contractor shall modify manufacturers' standard diagrams, charts, illustrations, brochures, calculations, schematics, catalog cuts, and other descriptive data to delete information which is not applicable to the Contract. The Contractor shall supplement standard information with additional information applicable to this Contract, and indicate dimensions, clearances, performance characteristics, capacities, wiring and other diagrams, and controls.

B. If the Contractor utilizes drawings prepared by others, such drawings may include the standards and symbols of others if the drawings are a mix of existing product drawings and drawings prepared specifically for this Contract. In the event others provide drawings prepared specifically for this Contract, such drawings shall conform in symbols, media and standards to the Contractor's drawings.

C. The Contractor shall modify the manufacturer's printed installation, erection, application, and placing instructions to delete information which is not applicable to the Contract.

D. Submittals shall include the following:

1. Date and revision dates.

2. Contract title and number.

3. Reference Contract Drawing numbers.

4. Applicable Contract Specification Section numbers.

5. Identification of product by either description, model number, style number, serial number, or lot number.

6. The names of the Contractor, Subcontractors, Suppliers, and manufacturers as applicable.

7. Applicable standards, such as ASTM or Federal specification numbers.

E. Certificates of Compliance:

1. The Engineer may permit the use of certain materials prior to sampling and testing if accompanied by a certificate of compliance stating that the materials involved comply in all respects with the requirements of the Contract Documents. The certificate shall be signed by the manufacturer of the material. A certificate of compliance shall be furnished with each lot of material delivered to the Work, and the lot so certified shall be clearly identified in the certificate.

2. Materials used on the basis of a certificate of compliance may be sampled and tested at any time. The fact that material is used on the basis of a certificate of compliance shall not relieve the Contractor of responsibility for incorporating material in the Work which conforms to the requirements of the Contract Documents. Any such material not conforming to such requirements shall be subject to rejection whether in place or not.

3. The Engineer reserves the right to refuse the use of material submitted for approval solely on the basis of a certificate of compliance.

4. The form of the certificate of compliance and its disposition shall be as approved by the Engineer.

1.10 SAMPLES

A. The Contractor shall furnish to the Engineer samples required by the Contract Documents. Samples shall be submitted without charge, with shipping charges prepaid. Materials for which samples are required shall not be used in the Work until approved in writing by the Engineer.

B. Sample Label: Each sample shall be labeled with the following data:

1. Name, number, and location on project;

2. Name of Contractor;

3. Material or equipment represented, and location in the project;

4. Name of producer, brand, trade name if applicable, and place of origin; and

5. Date of submittal.

C. The Contractor shall forward a letter in triplicate to the Engineer submitting each shipment of samples and containing the information listed on the Sample Label specified herein. Approval of a sample shall be only for the characteristics and use named in the submittal and approval, and shall not be construed to change or modify any Contract requirement. Before submitting samples, the Contractor shall assure itself that the materials or equipment will be available in the quantities required in the Contract, as no change or substitution shall be permitted after a sample has been approved unless such change or substitution is approved by the Engineer in writing.

D. Samples of material from local sources shall be taken by or in the presence of the Engineer. Samples taken otherwise shall not be considered for testing.

E. Inspection and tests will be made, but it is understood that such inspections and tests, if made at any point other than the point of incorporation in the Work, in no way shall be considered as a guaranty of acceptance of any material which may be delivered later for incorporation in the Work.

F. Approved samples not damaged in testing may be incorporated in the finished work if marked for identification and approved by the Engineer. Materials incorporated in the Work shall match the approved samples.

G. Failure of any material to pass the specified tests shall be sufficient cause for refusal to consider, under the Contract, any further samples of the same brand, make, or source of that material. The Engineer reserves the right to disapprove any material which has previously proven unsatisfactory in service.

H. Samples of material delivered to the site or installed in place may be taken by the Engineer for testing. Failure of samples to meet Contract requirements shall annul previous approvals of the item tested.

PART 2 – PRODUCTS

Not Used

PART 3 – EXECUTION

Not Used

END OF SECTION 01 33 23

SECTION 01 35 11

BART AND THIRD-PARTY VENDOR RELOCATIONS

PART 1 – GENERAL

1.01 GENERAL DESCRIPTION

A. This Contract Specifications Section includes requirements for the temporary removal, relocation, and reinstallation of equipment and facilities for third-party vendors at the BART stations, where necessary, to accommodate renovation and retrofit work. This work may include temporary storage of third-party equipment and facilities. This work may also require some equipment and facilities to remain in place with proper and adequate protection.

The term “third-party vendors”, as used in these Specifications, are vendors authorized by BART to provide goods and services, within or near the station. These vendors include providers of:

1. Bike storage, including lockers and racks.
2. Advertising signage.
3. Food and other items in permanent facilities or on rolling carts.
4. Printed media sold or distributed at counters or on racks.
5. Telephones.
6. Mailboxes.
7. Other types of third-party equipment and facilities as identified and designated in the Contract Documents.

B. The Contractor is responsible for the removal, temporary relocation, storage, if required, and re-installation of the third-party equipment and facilities and indicated and described in the Contract Documents. BART, a third-party vendor, or both may require that a designated party, other than the Contractor remove, relocate, store, and reinstall the equipment and facilities.

C. The Contractor shall furnish and install electrical devices, conduits, conductors, lighting, accessories, and equipment required to allow for the continuous operation of the BART or third-party vendor equipment and facilities regardless of the party temporarily relocating or reinstalling the facility or equipment.

D. The Contractor shall furnish and install anchorages in concrete surfaces at the station where required and necessary for the proper operation and function of a BART or third-party vendor facilities and equipment regardless of the party temporarily relocating and reinstalling the facilities and equipment.

E. Prior to the completion of construction, the temporarily relocated BART and third-party equipment and facilities shall be reinstalled at the original locations unless otherwise directed by the Engineer. The equipment and facilities shall be reinstalled to the condition existing before removal.

F. The Contractor shall also relocate equipment owned by BART as indicated in the Contract Drawings including benches, fences, railings, trash containers, trash receptacles, and other station furnishings Prior to the completion of construction, the Contractor shall reinstall the BART equipment and furnishings to the original locations unless otherwise directed by the Engineer. The equipment and facilities shall be reinstalled to the condition existing before removal.

1.02 MEASUREMENT AND PAYMENT

A. Separate measurement and payment will not be made for Work required under this Section. All costs in connection with the Work specified herein shall be considered to be included as part of the Contract lump sum price indicated in the Bid Schedule of the Bid Form for the related item or items of Work.

1.03 RELATED SECTIONS

1. Contract Specifications Section 01 32 16, Construction Progress Schedules
2. Contract Specifications Section 01 32 33, Photographic Documentation
3. Contract Specifications Section 01 35 14, Operating System Interface
4. Contract Specifications Section 01 57 00, Temporary Controls
5. Contract Specifications Section 01 71 23, Field Engineering
6. Contract Specifications Section 06 10 00, Rough Carpentry
7. Contract Specifications Section 09 91 00, Painting
8. For electrical requirements, refer to Sections in Division 26, Electrical.
9. For communications requirements, refer to Sections in Division 27, Communications.

1.04 SUBMITTALS

A. Prior to the removal and relocation of BART or third-party vendor items, the Contractor shall photograph, as existing in place, the BART and third-party vendor items that will be relocated or protected in place during construction, in accordance with Contract Specifications Section 01 32 33, Photographic Documentation.

B. The Contractor shall submit a “Contractor Work Plan” as described in Part 3 of these Specifications.

C. The Contractor shall submit a relocation/reinstallation anchorage and detail plan (RRADP), as described in Part 3 of these Specifications, for keyed bike lockers, electronic bike lockers, advertising signs, news vendors, news racks, and BART equipment and station furniture not less than 30 Days before the scheduled relocation date. The Contractor shall provide to the Engineer a list of facilities and equipment to be stored and the storage location, in advance of removing facilities and equipment.

PART 2 – PRODUCTS

Not Used.

PART 3 – EXECUTION

3.01 COORDINATION

A. The Contractor is responsible for coordination with the third-party vendors, through the Engineer, of the relocations/reinstallations to prevent interruption to the function/operation of the BART and third-party equipment and facilities and shall direct all matters regarding the relocations/reinstallations to the Engineer.

B. The electronic bike locker manufacturer, the electric advertising sign manufacturer, Titan Worldwide, Public Telephone Service (“PTS”), and USPS may relocate and reinstall the corresponding third-party equipment and facilities. If these third-party vendors cannot relocate/reinstall on the proposed relocation/re-installation date, the Contractor shall revise the proposed date to a mutually agreeable date with these third-party vendors. There is no time extension allowed due to a mutually agreeable revised relocation/re-installation date.

C. The Contractor shall confirm the final details with the third-party vendors through the Engineer not less than 14 Days before the scheduled relocation/reinstallation.

3.02 CONTRACTOR WORK PLAN

A. The Contractor shall submit, as a part of the Work Plan, the construction staging plans identifying the existing and proposed locations of the BART and third-party vendor equipment and facilities to be relocated. The staging plans shall reflect the existing and proposed locations, as indicated and described in the Contract Drawings, of the BART and third-party vendor equipment and facilities to be relocated for the corresponding stage of construction.

B. The staging plans shall be in sufficient detail to coordinate the relocation and to ensure that the relocated equipment and facilities will remain functional and operational after the relocation. The proposed relocations shall not interrupt station operations including, the exit path of travel, station and vendor equipment, facilities that remain in place, and any other functions or facilities that may be affected.

3.03 RELOCATION/REINSTALLATION ANCHORAGE AND DETAIL PLAN (RRADP)

A. The Contractor shall perform a pre-construction survey in accordance with Contract Specifications Section 01 71 23, Field Engineering, to identify and confirm existing embedded conduits, duct bank, piping, reinforcing, and other embedded items. The areas of work shall be cleaned for layout purposes, and masking tape with permanent ink, or other methods approved by the Engineer, shall be used to layout all existing embedded items. The Contractor shall protect the layout markings prior to drilling in concrete and shall remove the layout material after the relocation/reinstallation is completed.

B. The RRADP shall be developed from the pre-construction survey of the existing embedded items. The plan shall include, at a minimum, the details for disconnecting and removing the BART and third-party vendor equipment and facilities from existing locations, placement and anchoring in the temporary locations, and restoration to the original locations.

C. The Contractor is responsible for providing conduits and conductors for connecting the electronic bike lockers, electric signs, and telephones at the temporary location from the power outlet or source at the original locations. The Contractor shall submit, as part of the RRADP, the proposed routing of the electrical conduits and wiring. The conduits and conductors shall not interrupt station operation. Interruption to exit path of travel is absolutely forbidden.

3.04 FOUR-WEEK WORK PLAN

A. All BART and third-party vendor equipment and facilities to be relocated shall be identified and the corresponding relocation and reinstallation activities scheduled on the Four-Week Work Plan in accordance with Contract Specifications Section 01 32 16, Construction Progress Schedules.

B. The Contractor is solely responsible for all delays and will not be granted time extensions or additional compensation if the Contractor fails to include and update the Four-Week Work Plan with the corresponding relocation and reinstallation activities.

3.05 RELOCATION/REINSTALLATION

A. The Contractor shall install the anchorages for BART and third-party vendor equipment and facilities at the jobsite locations in accordance with the pre-construction survey and the approved RRADP. The Contractor is responsible for protecting the surveyed layout markings and shall perform additional survey at the Contractor's own expense if the markings are damaged or removed prior to anchorage installation. The Contractor shall exercise care during the installation to prevent damaging existing embedded items, and relocated/reinstalled equipment and facilities. The Contractor shall repair damage at its own expense and as approved by the Engineer.

B. The Contractor shall protect existing anchorages of existing facilities and equipment in place. Existing anchorages which may create a tripping hazard or project from a

wall where people may be present and all temporary anchorages shall be removed. The Contractor is responsible for removing the embedded anchors to a 1-inch minimum depth and patching all anchor holes when removing the BART and third-party vendor equipment and facilities from the original position or from the temporary relocated locations.

C. Prior to drilling for the new anchors, the Contractor shall perform a nondestructive survey for detecting conduits, duct banks, piping, bar reinforcement or other embedded items in the foundation. The survey method may include ground penetrating radar (GPR), Seektech, Ferroscan, or equal equipment.

3.06 BIKE LOCKERS AND BIKE RACKS

A. The Contractor shall store or stockpile equipment or materials away from bike lockers or bike racks to prevent blocking passenger access.

B. The Contractor shall plan all bike locker or bike rack relocations, as indicated, and submit the plans and schedules for review and approval as part of the Contractor Work Plan and Contract Schedule. The plan shall include, at a minimum, the details for disconnecting the lockers and racks from the original anchors, locker and rack removal, placement and anchoring in the new location, and restoration of the original location. Restoration shall include anchor removal to a 1-inch minimum depth and patching of all holes from the original anchors.

C. Bike locker and rack relocations shall be performed on weekend days, when there are fewer bikes in the lockers and racks.

1. Keyed Bike Lockers: On the morning of the bike locker relocation, the Contractor, with the Engineer, shall jointly inspect the bike lockers and prepare an inventory of any contents found in each locker. The Contractor shall provide a temporary secured holding area or container for temporary storage after the Engineer completes the tagging of each item. The Contractor shall lock each locker after the Engineer completes the inspection and documentation of items found in the lockers. The Contractor shall move each locker assuring no damage to the lockers and the original locker location, and secure the lockers to the new approved location with the same size anchors as used at the original locker locations. The Contractor shall return, with the assistance of the Engineer, all of the locker contents to the same lockers from which the contents were removed.

2. Electronic Bike Lockers: The Contractor shall submit, for review and approval, a work plan including a more detailed layout than the layout provided in the Contract Documents of where the bike lockers are to be relocated. The slope where the lockers will be relocated shall not exceed two percent. The Contractor shall notify the Engineer two weeks in advance confirming that the bike locker relocation by the bike locker manufacturer will occur as scheduled. The Engineer will notify the bike locker manufacturer to make arrangements and to take responsibility for relocating the lockers. On the morning of the bike locker relocation, the Contractor, with the Engineer, shall jointly inspect the bike lockers and prepare an inventory of any contents found in each locker. The Contractor shall provide a temporary secured holding area or container for temporary storage after the Engineer completes the tagging of each item. The Contractor

shall lock each locker after the Engineer completes the inspection and documentation of items found in the lockers. The manufacturer shall move and secure each locker at the new approved location. The Contractor shall return, with the assistance of the Engineer, all of the unidentified items to the same lockers from which the contents were removed.

3. Bike Racks: Two Days prior to the relocation, the Contractor shall place yellow caution tape around the bike racks to prevent usage prior to the relocation date. On the morning of the bike rack relocation, the Contractor, with the Engineer, shall jointly inspect the bike racks and prepare an inventory of any bikes found in each rack. The Contractor shall provide a temporary secured holding area or container for temporary storage of these bikes after the Engineer completes the tagging of each bike. The Contractor shall move each rack, assuring no damage to the racks, and secure the racks to the new approved location using the same size anchors as the original rack anchors.

3.07 ADVERTISING SIGNS

A. The Contractor's equipment or materials shall not be stored or stockpiled in a way that blocks BART passenger visibility of advertising signs that are not designated to be relocated as part of the Work.

B. The Contractor shall plan all sign relocations and submit the plan for review and approval as part of the Contractor's Work Plan and Contract Schedule. The plan shall include, at a minimum, the details for disconnecting the signs from the original locations, coordinating with the sign manufacturer for sign removal, sign relocation, and placement in the new location. The Contractor shall provide restoration of the original location including acceptable removal and patching of the original anchors, if necessary.

C. The Contractor shall protect, in place, the existing non-powered and powered signs if the signs are designated to remain during the work. If the signs cannot remain in place due to interference with the Work, the Contractor shall provide seven Days advance notification to the Engineer prior to the planned date to have the signs relocated or removed and stored by the sign manufacturer. Where possible, Contractor shall place the signs and frames on a wood wall enclosure in as close to the original orientation as possible, maintaining comparable visibility. The wood wall enclosure shall consist of plywood at least 5/8 inch thick, a minimum of eight feet high and supported in a manner that does not cause a safety hazard or damage to adjacent permanent surfaces. The plywood and support lumber shall be non-combustible material in compliance with Contract Specifications Section 06 10 00, Rough Carpentry. The face of the wall -enclosure shall be painted white with exterior grade flat latex paint, in accordance with Contract Specifications Section 09 91 00, Painting, prior to sign placement.

1. Non-Powered Signs:

    a. Contractor shall provide 30 Day notification to the Engineer prior to relocation of advertising signs and frames.

b. Contractor shall be responsible for replacement of lost or broken signs or frames caused by relocation Work.

c. Contractor shall provide 30 Day notification to the Engineer prior to removing the temporary wooden wall enclosure and signs. After the retrofit work is completed and after the temporary signs are removed by the sign manufacturer, the Contractor shall remove and dispose of the temporary wall enclosure. The Contractor shall remove any physical protection for signs that are protected in place. The Contractor shall restore all permanent surfaces that may have been damaged during the sign relocation and removal process.

2. Powered Signs:

a. Contractor shall provide 30 Day notification to the Engineer prior to relocation of advertising signs and frames.

b. Contractor shall request a date for BART to unlock the frames.

c. Contractor shall be responsible for replacement of lost or broken signs or frames caused by relocation Work.

d. Contractor shall coordinate with the Engineer to disconnect and reconnect electrical signs.

e. Contractor shall provide 30 Day notification to the Engineer prior to removing the temporary wood wall enclosure. After the Work is completed and following the relocation of the powered signs by the sign manufacturer, the Contractor shall reconnect the sign in its original location, or in the pre-approved new location as indicated in the Contract Drawings, run any required conduits and wiring, and power up the sign.

f. Contractor shall remove all temporary conduit, wiring, and supports no longer needed and restore all permanent surfaces that may have been damaged during the sign relocation and removal process.

3.08 PERMANENT VENDORS, ROLLING CART VENDORS, NEWS VENDORS, NEWS RACKS, TELEPHONES, AND MAILBOXES

A. No Contractor equipment or materials are to be stored or stockpiled in a way that blocks permanent vendors, rolling cart vendors, news vendors, news racks, telephones, and mailboxes.

B. The Contractor shall plan all the relocations of vendors referenced in this Article and submit, for review and approval, as part of the Contractor Work Plan and Contract Schedule. The plan shall include, at a minimum, the details for disconnecting the rolling cart vendors, news vendors, news racks, telephones, and mailboxes from the original anchors; vendor equipment removal; placement and anchoring in the new location; and restoration of the original location including acceptable removal and patching of the original anchors. The Contractor shall comply with the Article entitled “Coordination” in these Specifications.

C. Except for telephone and mailbox relocation, that will be moved by the Public Telephone Service (PTS) and the U.S. Postal Service (USPS); each move, including

preparation, relocation, temporary anchoring, and return to original location following retrofit work, shall be performed by the Contractor, as approved by the Engineer. Any necessary permanent surface restoration work shall be provided by the Contractor.

D. Permanent Vendors: Permanent vendors shall remain in place. The Contractor shall take all necessary measures to protect the permanent vendors from disruption, noise, dust, and damage to facilities as approved by the Engineer and as required by Contract Specifications Section 01 57 00, Temporary Controls, and other applicable requirements of these Contract Documents. In the event that the Contractor's failure to comply with these requirements adversely affects BART, the permanent vendors, or both, the Contractor will be assessed in the approval of the monthly progress payments for all costs incurred by BART or the affected permanent vendors.

E. Rolling Cart Vendors: The Contractor shall provide notification to the Engineer on the planned date of relocating any rolling cart vendors.

F. News Vendors: The Contractor shall provide notification to the Engineer on the planned date of relocating any news vendors.

G. News Racks: The Contractor shall provide 60 Day notification to the Engineer on the planned date of relocating, protecting in place, or moving any news racks.

H. Telephones: Contractor shall provide 60 Day notification to the Engineer on the planned date for relocating, protecting in place, or moving any telephones. PTS will perform any telephone relocation or moves. The Contractor shall maintain a minimum of the following:

1. One working telephone inside the fare gates of the station.

2. One working telephone outside the fare gates. This phone shall be the American Disabilities Act (ADA) compliant phone.

3. One working telephone on each platform. This phone shall be the (ADA) compliant phone.

4. Maintain Telecommunication Device for the Deaf (TDD) in the current location or relocate on the same floor prior to obstructing TDD phones.

    a. Fourteen Days prior to the relocation, the Contractor shall notify the Engineer confirming the final details of the Work Plan and schedule for telephone relocations, so that the Engineer can notify PTS to prepare to move the telephones as scheduled.

I. Mailboxes (USPS): The Contractor shall provide 60 Day notification to the Engineer on the planned date for relocating, protecting in place, or moving any mailboxes. USPS will perform any mailbox relocation. 14 Days prior to the relocation, the Contractor shall notify the Engineer confirming the final details of the Work Plan and schedule for mail box relocations so that the Engineer can notify USPS to prepare to move the mailboxes` as scheduled.

3.09 FACILITIES AND EQUIPMENT TO REMAIN IN PLACE OR STORED

A. Equipment and facilities that remain in place and are not functional or operational shall be protected from damage.

B. Contractor shall store equipment and facilities as indicated in the Contract Drawings or as directed by the Engineer. Facilities and equipment shall be stored in a manner as to maintain their quality and fitness for the Work. The Contractor shall store equipment and facilities in a place with similar or better environmental conditions, including exposure to sunlight and the weather.

END OF SECTION 01 35 11

SECTION 01 35 14

OPERATING SYSTEM INTERFACE

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Requirements for accessing the BART Operating System

B. BART Operating Rules and Procedures (OR&P)

C. Training

1.02 MEASUREMENT AND PAYMENT

A. Roadway Worker Protection (RWP) certification training and recertification will be provided by the District and measured and paid for as a unit price per manhour of training time as indicated on the applicable Bid Item in the Bid Schedule of the Bid Form. The District will not pay for worker hours spent in retraining and retesting required for Roadway Worker Protection certification.

B. Training time for District-provided training other than Roadway Worker Protection certification, as described in Article 1.07 herein, will be paid for as a unit price per manhour of training time as indicated on the applicable Bid Item in the Bid Schedule of the Bid Form. Contractor-developed and executed training is not included.

C. Watchperson activities will be measured and paid for as a unit price per manhour as indicated on the applicable Bid Item in the Bid Schedule of the Bid Form.

D. Separate measurement or payment will not be made for the remainder of the work required under this Section. All costs in connection with this work will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work.

1.03 DEFINITIONS

A. BART Operating Envelope: That portion of the BART system that has controlled access, including fan and transition structures, pump stations, train control, communication and traction power facilities and equipment, and BART Right-of-Way. For illustration of certain BART Operating Envelope configurations, refer to Attachments 1 thru 4.

B. BART Operating System: BART owned or operated facilities.

C. BART Right-of-Way (ROW): That portion of the BART system within protective fencing (including yards), tunnels, tubes, subways, aerial structures, facilities adjacent to or extending into the track zone, and station areas in or adjacent to the track zone.

D. Clear of Track: A location with at least 44 inches between you and the nearest running rail when a walkway with a handrail or other means of support/reference is present (wall, fences or in the case of yards and local control areas, a stationary train appropriately protected from movement). For aerial structures, Clear of Track is when personnel are on the aerial walkway and the EIC declares that the area is cleared for on-rail vehicles to traverse. For all other conditions, Clear of Track is defined as a location with at least 72 inches (6 feet) between you and the nearest running rail. These dimensions are for straight track; on curved track, additional clearance needs to be added for car body overhang.

E. Clearance: An official authorization which transfers control of an area or equipment to perform an activity subject to clearance rules.

F. Clearance Verification: A verification by the EIC to ensure that items constructed or modified within the Track Zone meet the minimum clearance envelope. Clearance criteria are specified in the BFS and shall be included in the SSWP, with detailed identification of each item to be verified and the method by which the clearance will be verified.

G. Detailed Site Specific Work Plan (SSWP): A program, plan, and schedule prepared and submitted by the Contractor and approved by the District, which accurately describes and illustrates the manner in which work shall be accomplished. See Attachment 5.

H. Employee-In-Charge (EIC): A Roadway Worker who is responsible for ensuring Roadway Worker safety, including use of Roadway Worker protections, at a Jobsite within the BART Operating Envelope, and who is authorized to accept and execute Work Orders. Work within the BART ROW, will require a BART employee to function as the EIC. For work outside of the BART ROW, a District representative may function as the EIC. The Contractor shall not function as the EIC. At the District's discretion, more than one EIC may be assigned to a work area when the District deems the area too large to be adequately controlled by a single EIC. In such situations, a primary EIC will be designated to accept and execute Work Orders.

I. Global Site Specific Work Plan (GSSWP): A notification prepared and submitted by the Contractor to the Engineer for all work within the BART Operating System, which provides all information as shown in the Attachment 6.

J. Return to Service Checklist: A checklist showing required activities to return the BART system to service.

K. Revenue Hours: Hours during which passenger carrying trains operate as defined by the current schedule and which may be modified by the BART Operations Control Center (OCC).

L. Roadway Worker: A person currently certified by the District's Roadway Worker Protection (RWP) Certification Program.

M. Safety Escort: A Roadway Worker employed by the Contractor and who is responsible for up to five (5) persons in the ROW, Oakland Transition Structure, San Francisco Transition Structure, or Transbay Tube Lower Gallery who are not

qualified as Roadway Workers. The Safety Escort shall participate in the job safety briefing; possess and be competent to use a District-supplied working radio; stay in continuous contact with the EIC; and ensure that escorted individuals remain safe, stay within the limits of the work area, and do not violate OR&P rules and procedures. A Safety Escort is allowed to perform other work.

N. Track Zone: An area within 72 inches (6 feet) of the outside rail on both sides of the track.

O. Watchperson: A Roadway Worker, whose sole duty is to remain in a position to provide effective warning in compliance with the 15-second rule to persons of approaching rail transit vehicles, including trains or any on-rail equipment; who does not perform or assist in any other work aside from the Watchperson duty; possesses and is competent to use a District-supplied working radio, and who remains Clear of Track of all active track(s). A Watchperson shall have the means to notify the crew and shall be required for all work in the Track Zone.

P. Work Orders: A formal communication between the EIC and the control center having jurisdiction to establish authorization to work.

Q. Work Week: The time period starting with 0001 hours Monday and ending at 2359 hours of the following Sunday.

1.04 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures for submittal requirements and procedures.

B. Detailed Site Specific Work Plan (SSWP): The detailed SSWP shall be submitted no later than 42 calendar days prior to the scheduled start of the work addressed by the SSWP. Each resubmittal of the SSWP shall require an additional 42 calendar days of review time.

C. Global Site Specific Work Plan (GSSWP): Contractor shall submit GSSWP to the Engineer for approval.

D. Training Plan: Submit training plan and training materials for Contractor training in accordance with Article 1.07 Training herein.

1.05 ACCESS INTO THE BART OPERATING SYSTEM

A. Access to the BART Operating System shall be in accordance with BART publication, “Standard Procedure for Access to the BART Operating System” (Management Procedure – 31). A copy of Management Procedure 31 will be provided by the District upon request.

B. Global Site Specific Work Plan (GSSWP): The GSSWP shall remain in effect for the duration of the Work unless any element of the GSSWP is changed, at which time the Contractor shall resubmit.

C. Detailed Site Specific Work Plan (SSWP)

1. The SSWP is required prior to starting work that may affect the BART Operating Envelope, station paid areas, or has the potential to impact mission-critical systems regardless of location. Mission-critical systems include:

   a. Station or trackway fire water supply lines, or appurtenances

   b. Station fire alarm conduits, cables, duct banks, or appurtenances

   c. Traction power conduits, cables, duct banks, or appurtenances

   d. Station electrical conduits, cables, duct banks, or appurtenances

   e. Train control and communications conduits, cables, duct banks, or appurtenances

   f. Emergency egress pathways

   g. Fare collection equipment

2. The Contractor shall furnish labor, materials, and equipment as required to perform and complete the Work in the limited time available. The Contractor shall maintain the approved schedule in the SSWP.

3. Detailed SSWPs, shall include a detailed schedule for each activity in the SSWP. The schedule shall show the expected work progress for each activity on an hourly basis. Depending on the complexity of the work, the work schedule may be required to be broken down into 15-minute increments through the period covered by the SSWP. The schedule shall include a time at which activities planned under the SSWP will be completed. Failure of the Contractor to complete the scheduled activities by the planned time, or to put in place an approved contingency plan so that the system is available for operations at the approved completion time, shall make the Contractor liable for Liquidated Damages as specified in Section 01 11 00, Summary of Work.

4. The SSWP shall contain a description of differences to the BART Operating Envelope between the start and finish of the work. The SSWP shall show each activity and where and how it affects normal operation of the system. Each activity in the SSWP shall include labor, materials, and equipment required to complete the activity, including operating and physical data of the equipment. The SSWP shall include an assessment of any BART personnel (EIC, Electrician, Inspector, Technician, and similar personnel) necessary to complete the work.

5. The SSWP shall include contingency plans for putting the system back in operation in case of an emergency or in case the Contractor fails to perform and complete the work in accordance with the approved schedule. Contingency plans shall address the various stages of work.

6. District reserves the right to delay approval of the SSWP until applicable Submittals required for the Work in the SSWP have been approved.

7. Approval of the SSWP does not relieve the Contractor from fulfilling Contract requirements.

8. A copy of the District approved SSWP shall be on site during the work performed.

9. The SSWP shall remain in effect for the duration of the Work. When changes are required, the Contractor shall resubmit a revised SSWP for the District's approval prior to continuation of Work.

D. A minimum of one Watchperson is required for each work area within the Track Zone. Additional Watchpersons are required if one Watchperson is unable to provide effective warning in compliance with the 15-second rule for all personnel. Watchpersons shall have a District-supplied working radio in their possession. Watchpersons shall not transmit on the radio except when acknowledging an EIC's instruction or during an emergency. The Contractor shall provide Watchpersons as required by this specification and by SSWP requirements. Watchpersons shall remain in place at all times when personnel are in the Track Zone.

E. Employee in Charge (EIC) Responsibilities:

1. Refer to the OR&P Section 8300.

F. System Access Committee

1. The System Access Committee (SAC) is a standing BART committee that controls the System Access process by which work in the BART Operating System is authorized. The SAC authorizes the work to be scheduled to gain access to the BART Operating System. The SAC meets each Wednesday to consider and approve work to be performed during the Work Week following the meeting.

2. Work in the BART Operating Envelope requires the issuance of formal Work Orders, which must be pre-authorized through the approval of a System Access Request. Work outside of the BART Operating Envelope but within the BART Operating System requires a System Access Request to be submitted as an "Advisory" notification. No work may be permitted on BART property without an approved System Access Request.

3. Contractors shall submit each individual request for access to the BART Operating System to the Engineer in writing no later than Thursday before the SAC meeting. The request shall include actual hours that work will be performed and required support by BART forces, including the number of EICs needed. The District will not approve access request without an approved detailed SSWP or GSSWP, as applicable.

4. The necessary resources to perform the work represented by the SSWP or GSSWP shall be available and demonstrated ready for use on the Friday prior to the Work Week. After verification of the availability of the required resources and confirmation of an approved SSWP and access request, the Engineer will issue a final decision as to whether work proceeds as planned.

5. For work within the BART Operating Envelope, the Contractor may not enter the Jobsite until authorization is obtained by the EIC. For work outside of the BART Operating Envelope, the District Representative or Contractor shall notify the control center having jurisdiction immediately prior to entering the Jobsite and immediately after departing.

1.06 BART OPERATING RULES AND PROCEDURES

A. Activities within the BART Operating System shall comply with the Operating Rules and Procedures Manual (OR&P) and amendments per Operating Bulletins. A copy of the OR&P and amendments per Operating Bulletins will be made available by the District upon request. Violations of the OR&P will subject the Contractor to prompt and possible permanent exclusion from the Jobsite until the Contractor demonstrates knowledge of proper compliance procedures to the satisfaction of the District. Such exclusion from the Jobsite will not be grounds for additional compensation or extension of the Contract completion time.

1.07 TRAINING

A. Personnel attending District administered training must first receive proper District issued ID badge in accordance with Section 01 35 54, Identification and Security.

B. For work within the BART Operating Envelope:

1. Roadway Worker Protection (RWP) certification training: The District will provide this training to Contractor personnel, as required. The training consists of 40 hours of instruction on safe roadway practices and radio proficiency. The District will administer testing on these subjects at the conclusion of the training period. An individual who fails the testing for safe roadway practices must pass a retest in order to be certified. An individual who fails only the radio proficiency test will take a supplementary radio instruction and must pass a retest of radio proficiency in order to be certified. If the worker fails either retest, the District will disqualify the worker from eligibility for Roadway Worker certification. Worker hours for retraining and retesting shall not be charged to the District. The Roadway Worker certification is valid for two years. Prior to expiration of the certification, the individual must attend an 8-hour recertification class and must pass tests for safe roadway practices and radio proficiency. Supervisors and Health and Safety Representative(s) (HSR) are required to be RWP certified.

2. Designated Contractor Roadway Workers are responsible for training employees of the Contractor and its Subcontractors who have not completed the RWP training and who are scheduled or expected to perform work within the BART Operating Envelope. This training shall be at a minimum, four hours in length. These employees are required to have successfully completed training within the previous 24 months before being allowed to work within the BART Operating Envelope. The Contractor shall keep records of those successfully completing the course, and make such records available for review by the District upon request.

Designated Contractor Roadway Workers shall prepare a training plan and course materials for review and approval by the Engineer that shall include at a minimum the training information provided below:

a. Hazards of the required job duties and the methods to safely carry out those duties. Examples: third rail, running rail, active vs protected tracks, revenue vs non-revenue

b. Proper safety procedures to be used to adequately address those hazards. Examples: where to and where not to step, which track and when entry to that track can be made. No horse play. Rule 1101 of the OR&P applies to Contractors.

c. Importance of complying with all relevant safety rules. Examples: PPE, time, location, equipment, facility limits.

d. On-track safety rules and procedures that Contractor personnel are required to follow. Examples: meaning of blue light, red light, District approved physical barrier, no refuge zone.

e. Railroad track and the surrounding space within which on-track safety is required. Examples: fifteen second rule, no refuge zone, clear of track.

f. Compliance with on-track safety instruction given by persons responsible for on-track safety functions. Examples: role of EIC, role of the Watchperson, and no use of Personal Electronic Device (PED).

g. Signals given by a Watchperson and the procedures upon receiving a train approaching warning. Examples: emergency protocol, horns, whistle, stop, evacuation, time to secure the work area and leave.

3. Contractor personnel shall be trained as Roadway Worker(s) in sufficient numbers to supply an adequate number of Watchpersons and Safety Escorts to conduct the work.

C. For work outside the BART Operating Envelope:

1. The District will provide training and retraining every 24 months, for up to four supervisory-level personnel, one of whom shall be the HSR. The Contractor shall have at least one of these supervisors on the project at all times when working within the BART Operating System. The course is 4 hours long, and the trainees must pass the required exams to successfully complete the course. Certification as a Roadway Worker will satisfy the requirements of this Article.

2. Supervisory personnel trained in accordance with Article 1.07C.1 herein shall be responsible for training employees of the Contractor and its Subcontractors who have not completed the training and who are scheduled or expected to perform work within the BART Operating System. The training shall be a minimum of one hour in length. Employees are required to have a successfully completed training within the previous 24 months before being allowed to work within the BART Operating System. The Contractor shall keep records of those successfully completing the course, and make such records available for review by the District upon request.

3. Supervisors shall prepare a training plan and course materials for review and approval by the Engineer. Training shall include as a minimum, topics provided by the District. The District will provide these topics as part of the 4 hour training.

1.08 RETURN TO SERVICE CHECKLIST

A. In accordance with the District's policy, a Return to Service Checklist shall be completed prior to the return of any safety critical systems to service. The Contractor shall support the District and its representatives in preparing and implementing the Return to Service Checklist to ensure the elimination or mitigation of identified potential hazards. A Return to Service Checklist is provided as part of the SSWP template.

B. For any structure constructed by the Contractor within the Track Zone, Clearance Verification must be completed prior to the return of any safety critical systems to service. The Contractor shall remain on site and immediately available until clearance is verified by the EIC, train inspection has been completed, and all Work Orders and Clearances have been cleared by the control center having jurisdiction.

PART 2 – PRODUCTS

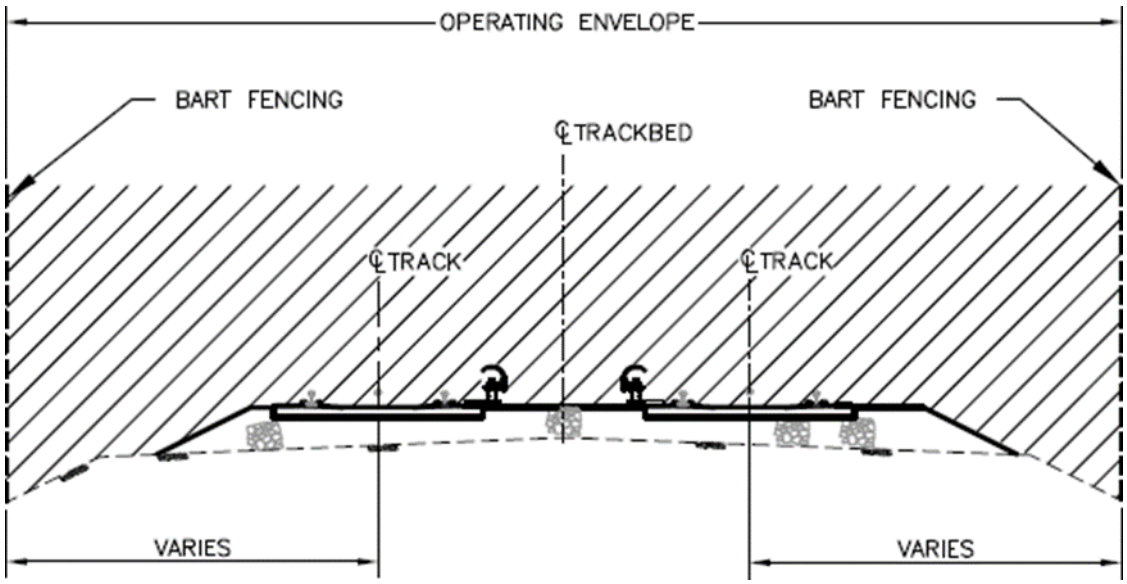
Not Used

PART 3 – EXECUTION

Not Used

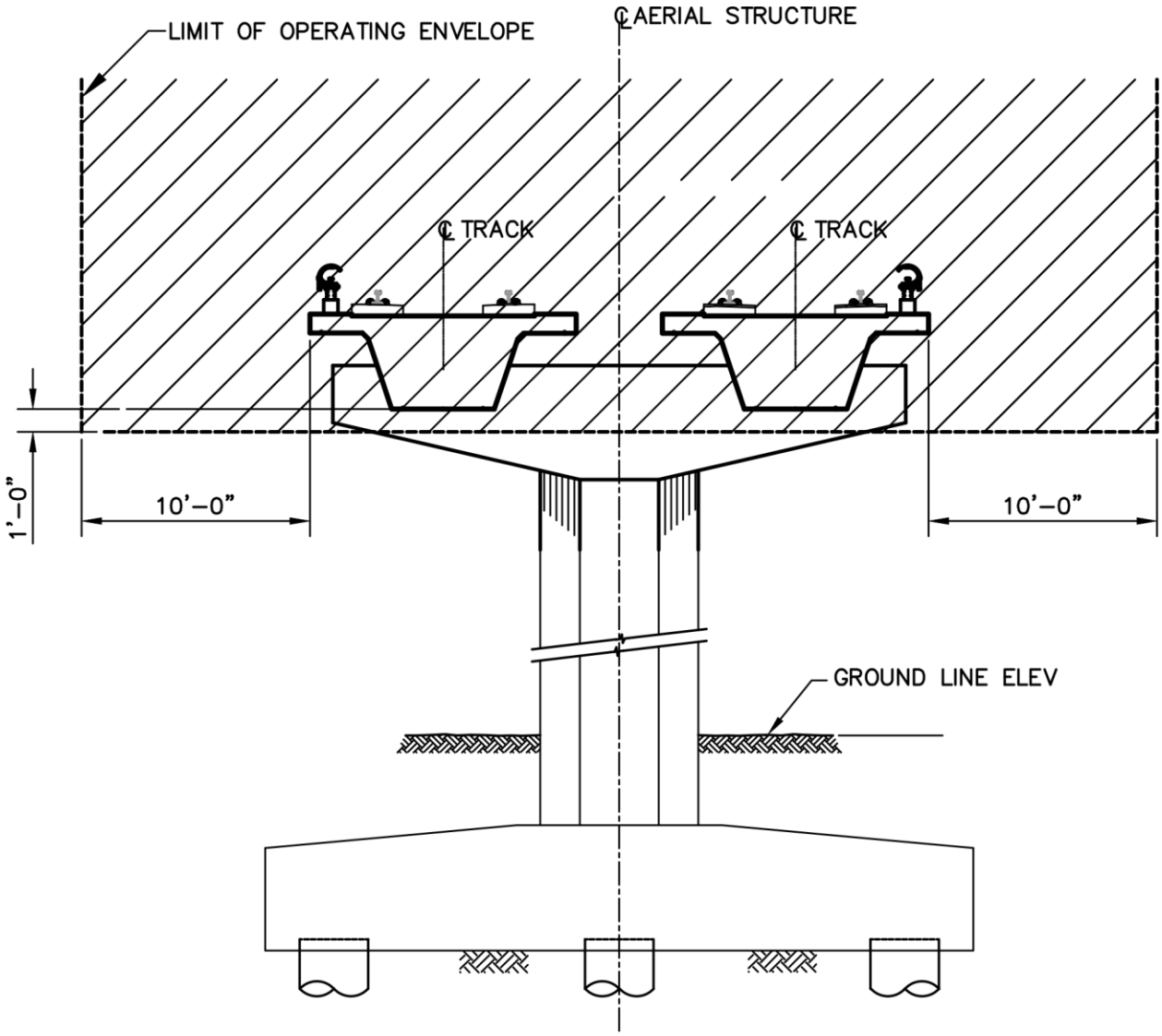
END OF SECTION 01 35 14

ATTACHMENTS TO FOLLOW



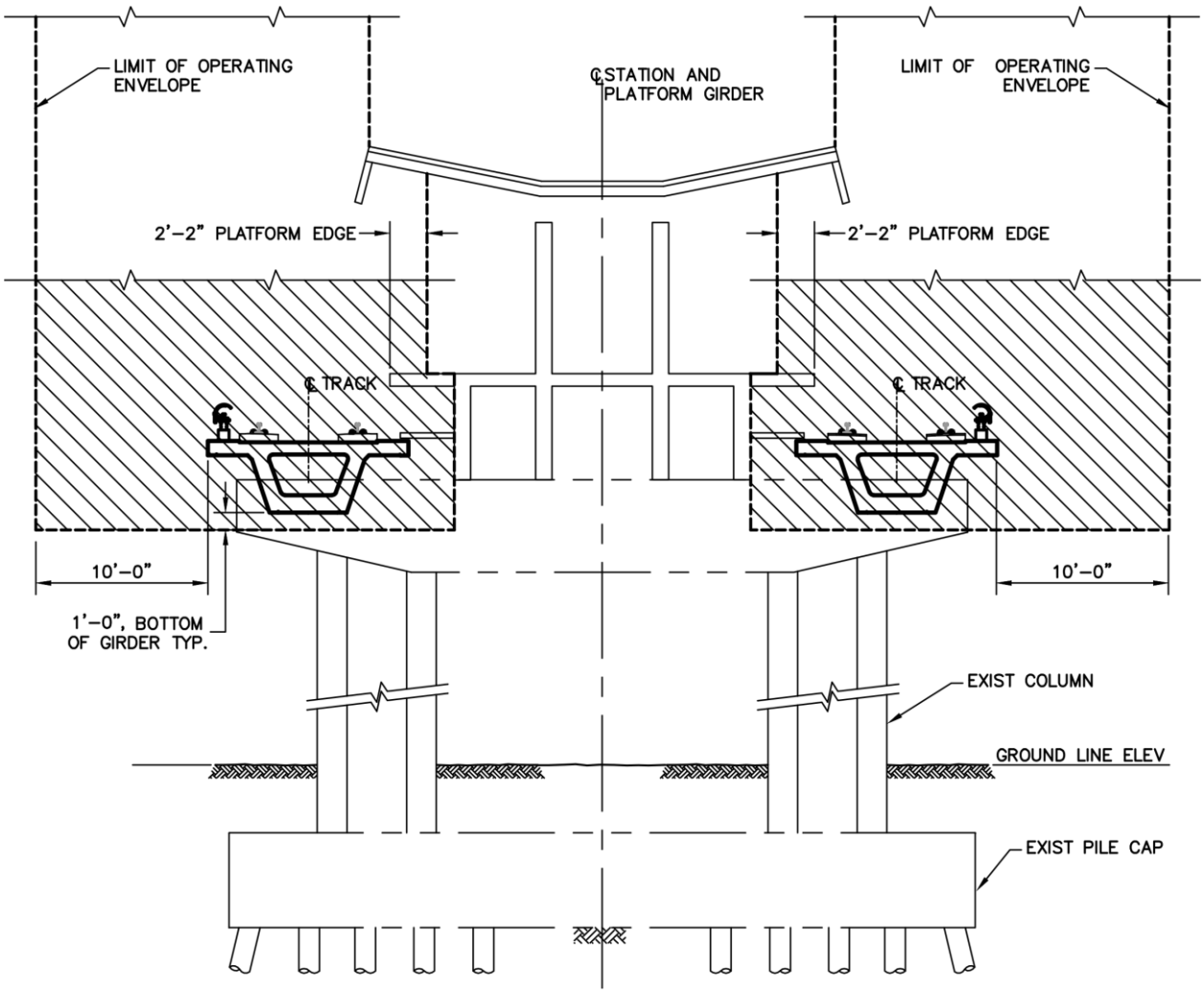
Attachment 1: BART Operating Envelope- Grade Track

Source: IL013361



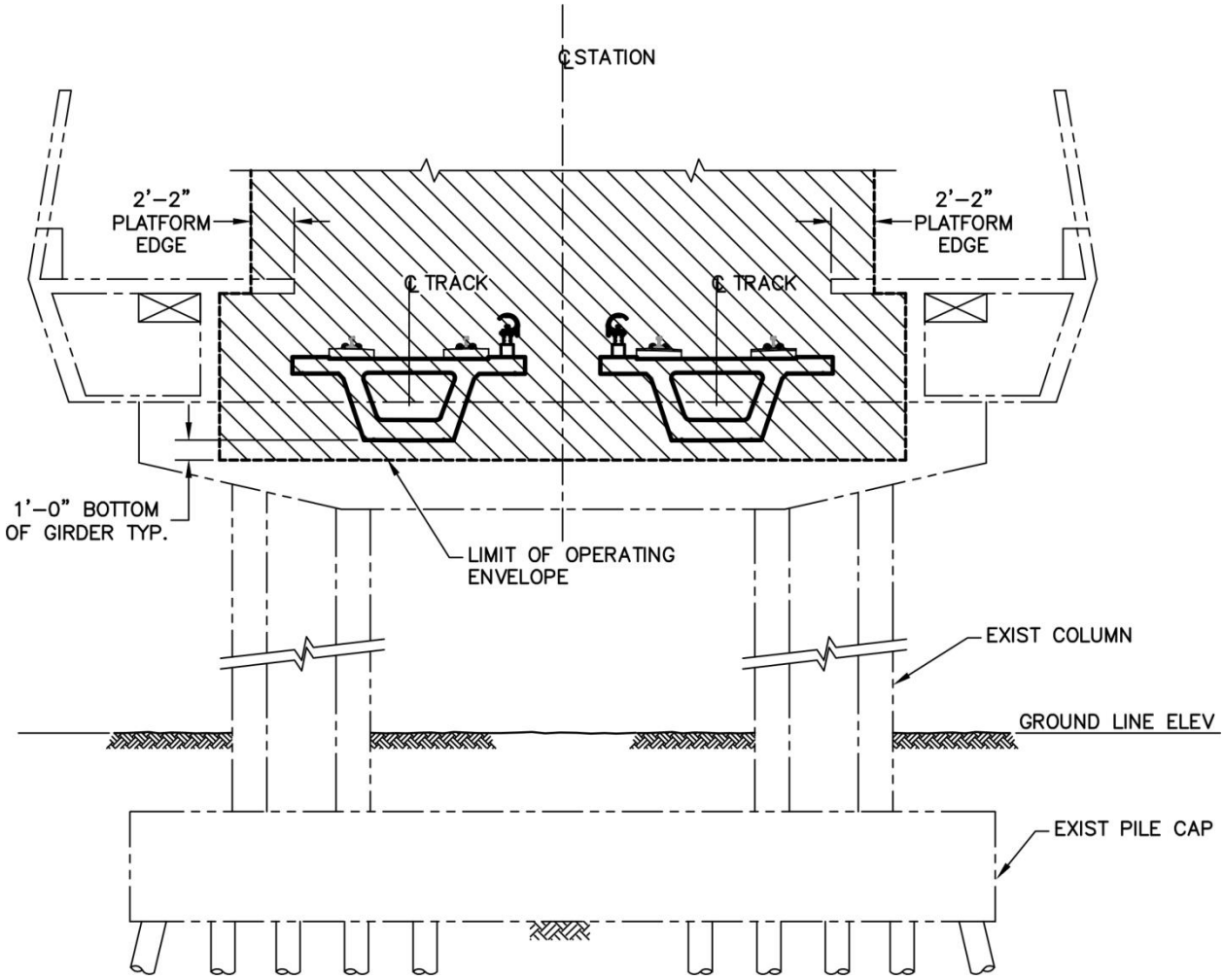
Attachment 2: BART Operating Envelope - Aerial Track

Source: IL013362



Attachment 3: BART Station Operating Envelope - Outside Track

Source: IL013363



Attachment 4: BART Station Operating Envelope - Inside Track

Source: IL013364

ATTACHMENT 5:
EXAMPLE OF DETAILED SITE SPECIFIC WORK PLAN (SSWP)

BAY AREA RAPID TRANSIT

[Contract Name]

CONTRACT # *[XXXX-XXX]*

Company Logo or Name

Date Submitted

SITE SPECIFIC WORK PLAN (SSWP) #*[X.X]*:

ADDENDUM LETTER (IF APPLICABLE)

[Submittal number]

BART Station/Facility Location Designation and/or Milepost (MP) location of work

* As applicable

Contractor: *[Contractor Name]*
Contract Number: *[XXXX-XXX]*

Submitted By:

Contractor [*Requester]*	Date
BART *[M&E System Access Committee Chair]*	Date

* As applicable

Project: *[project name]*

Contract No.: *[XXXX-XXX]*

Contractor: *[Contractor Name]*

Site Specific Work Plan: # *[X.X]*

Addendum Letter: *[X]*

Work Location: *[Specify by facility location designation, nearest cross streets and milepost]*

Work Hours (Military Time): *[List all work hours possible. Only these hours will be approved in System Access Requests]*

- Weekday: Monday thru Friday from *XXXX* hrs to *XXXX* hrs
- Saturday: *XXXX* hrs to *XXXX* hrs *(if applicable)*
- Sunday: *XXXX* hrs to *XXXX* hrs *(if applicable)*

I. DESCRIPTION OF WORK

{Define the general scope of work covered in this SSWP}

II. BART SYSTEM IMPACT

a. WILL THE WORK IN THIS SSWP BE LOCATED?

i. IN AN AREA OPEN TO THE PUBLIC?

- YES NO

ii. WITHIN THE BART RIGHT-OF-WAY (ROW)?

- YES NO

iii. WITHIN SIX FEET FROM THE NEAREST RUNNING RAIL (TRACK ZONE)?

- YES NO

iv. IN AN AREA IN CLOSE PROXIMITY TO UTILITIES TIED TO THE SYSTEM?

- YES NO

v. IN PROXIMITY TO THE BART ROW WHERE ACTIVITIES MAY POTENTIALLY IMPACT OR ENTER THE BART ROW?

- YES NO

b. Other BART Operating Facilities Potentially Affected by this Work

{List facilities and brief description of impact or potential impact}

* As applicable

III. SAFETY

a. Shift will start with a Safety Meeting for a minimum of 15 minutes, which must include the assigned EIC(s). All Safety Meetings shall include (at a minimum):
- **i.** All personnel must attend and discuss the Job Hazard Analysis (JHA) in order to identify all possible dangers or hazards in the work zone or job site.
- **ii.** Explanation of emergency evacuation procedures and egress points.
- **iii.** If work is in the ROW, or may affect the ROW, personnel must also be advised to be diligent when working in the near vicinity of the third rail and its cover board, to prevent injury, death, damage and delay to revenue service. Personnel shall not step, stand, sit or recline on the third rail cover board. Personnel shall not stand, sit or step on the running rail.
- **iv.** BART Employee in Charge (EIC) will conduct a Site Specific Safety Briefing prior to starting any work activity. All individuals that enter the worksite during the shift shall receive a Safety Briefing by the EIC.
- **v.** All personnel are required to sign the EIC Safety Briefing Roster.
- **vi.** The EIC will notify the crew when it is safe to begin work.

b. The approved Health and Safety Representative (HSR) or Assistant Health and Safety Representative (AHSR) will be onsite throughout the work shift.

c. If the BART EIC or District Representative sees any unsafe condition, he/she will stop the work and work will not re-start until the EIC gives the clear signal. Contractor shall assist with restoring safe conditions as required.

d. All employees will wear required personal protective equipment. Mandatory PPE includes
- **i.** BART approved safety vest
- **ii.** BART approved hard hats
- **iii.** Eye protection
- **iv.** Work boots
- **v.** Other PPE

e. BART Operations Rules & Procedures (OR&P)
- **i.** Rule 1101: The rules contained in this book apply to all District employees, Contractors and others working on BART property.

f. Types of Work Clearance (Work Orders) that may be Requested in Work Area (select only those that apply to this SSWP, delete those that do not apply):
- **i. Category A:** Non Track Zone Access: Defined as Access to mainline right-of-way where work does not encroach in the Track Zone (within six feet of outside rail on both sides of track).
- **ii. Category B:** Access to Track Zone: Defined as Access to the mainline right-of-way where work will encroach in the Track Zone (within six feet of outside rail on both sides of track).
- **iii. Category C:** Access to Yard Tracks: Defined as authorization to work a designated section of track(s) with specific limits in which protection from train movement has been provided.
- **iv. Category F:** Equipment/Facilities Clearance: Defined as an authorization to work on remotely controlled and monitored equipment, or work that may affect the operation of trains.
- **v. Category P:** Physical Barrier Clearance: Defined as authorization to access and work within the Right-of-Way in an area when the Roadway Workers are separated from the Track Zone by a District-approved physical barrier.

* As applicable

vi. **Category BL:** Blanket Work Area: Defined as mainline track areas between specified interlocking gates or between interlocking gates and end of line stations where train movement is prohibited on all tracks and access is controlled by a Blanket Area Supervisor.
vii. **Category Y:** Access to Yard: defined as authorization to work a designated section of a yard where work does not encroach into the Track Zone (within six feet of outside rail on both sides of track).
viii. **Advisory Work:** Work conducted in the Operating System that does not require the issuance of formal Work Orders. The control center having jurisdiction must be contacted by phone or radio before advisory work may commence.

g. Work Area Protection (OR&P Rule 6328)*: All Work Areas shall be restricted to a maximum speed of 27 MPH to include all adjacent tracks not separated by a District approved physical barrier. Determine whether the work to be conducted is Category A, B or C. The work area is protected from train movement by one or more of the following (select only those that apply to this SSWP):
i. Route prohibits
ii. Forced track occupancies or zero speed codes
iii. By operating trains in the area in manual mode and issuing movement instructions, restrictions and holds for train movement or Confirmed Hold
iv. Restricted speed
v. The insertion of switch machine cranks or flags
vi. Notification of reverse running trains shall be provided to Roadway Workers
vii. Blue Lights

h. Type of Electrical Protection Needed (Safe Clearance)*

i. Roadway Worker Protection
i. All Roadway Worker Protection rules will be strictly enforced. A Roadway Worker must have completed the BART Roadway Worker Protection Training (40 hours) and must have BART ID badge displaying “orange sticker” to validate that worker has completed training. Employee in Charge (EIC) will be on site at all times and shall lead and conduct job briefing.
ii. When escorting non-RWP Trained personnel in the trackway under work orders, one (1) Roadway Worker shall be responsible for a party of not more than five (5) non-RWP Trained individuals. Additional Roadway Workers are required for larger groups with a maximum of five (5) non-RWP Trained individuals per Roadway Worker. The responsible Roadway Worker shall stay with all non-RWP Trained personnel and possess a District-approved working radio at all times. The responsible Roadway Worker(s) shall not cancel the work orders until all personnel are physically clear of the work area. (OR&P Rule 6335).
iii. A minimum of one Watchperson will be required for each work area within the Track Zone. Additional Watchpersons will be necessary if one Watchperson is unable to provide effective warning in compliance with the 15-second rule for all personnel. All Watchpersons shall have a District-supplied working radio in their possession. The Watchperson shall not transmit on the radio except when acknowledging an EIC’s instruction or during an emergency. The Contractor shall provide Watchpersons as required by this specification and by SSWP requirements. Watchpersons must remain in place at all times when personnel are in the Track Zone and shall not leave the area unless directed by the EIC. A Watchperson may not perform or assist in any other work aside from the Watchperson duty, and remains Clear of Track of all active track(s).

* As applicable

iv. Red and Blue Lights shall be placed at work site according to OR&P Section V, Subsection 5700, Rule 5701 and 5702.

v. {*Contractor shall specify the number of Watchpersons that will be assigned to each shift, including their approximate location and the area where red and blue lights will be placed to protect the work area*}.

IV. REQUESTED BART SUPPORT (examples)

Request for Maintenance #: *[X]*

Request for Engineering #: *[X]*

Work Order #: *[X]*

a. Employee-in-Charge (EIC): required for work in the BART Operating Envelope or SSI Locations.
b. *Certified Track Inspector*
c. *Electricians, Communications, Grounds, Facilities etc.*
d. *Test trains (4 cars minimum)*
e. *District Equipment*

V. WORK DETAILS

a. Governing Codes and References
i. [BFS x.x]
ii. [other associated with this work]

b. **Work Scope** *{Define the scope of Work, schedule, cut-in requirements including requirements to restore or return facility and/or appliance to revenue service and any modifications to the Operating System between the start and finish of such work. Provide a step-by-step procedure on how the work is to be accomplished. This should be detailed enough to allow a non-engineer individual to understand the work that is being done. Include a general description of all activities necessary to perform any work within, or in close proximity to the Operating Envelope, or interfacing with remotely controlled or monitored systems. Detailed (structural, electrical, mechanical, etc.) calculations are not required – they should be approved beforehand and noted in the SSWP that they were reviewed and approved by the appropriate engineer.}*

c. **Work Schedule Breakdown** *{Provide times associated with the steps, as appropriate. Depending on the complexity of the Work, the work schedule may be required to be broken down into 15-minute increments through the period covered by the SSWP. Indicate critical decision points milestones where the work must be completed or points of no-return. Indicate which steps are to be conducted during non-revenue hours. Indicate if an "Electrical Safe Clearance" is required. Indicate if and when train service will be affected.}*

* As applicable

d. Equipment and Manpower *{List the equipment and man power associated with completing the work described, (e.g. back hoes, cranes, drills, Operators, Carpenters)}*

VI. SECURITY/CONTINGENCY PLANS

- Should any unauthorized person enter the site, they will be escorted out of the site and the BART Representative and BART Police notified.
- Upon request by proper authority the Operations Control Center (OCC), BART Police Department, and/or the BART Safety Department, etc. the Contractor will stop work immediately. The Contractor will return the site to a safe condition expeditiously and vacate the area as quickly and as safely as possible, lending all reasonable support to the restoration of revenue service if so requested.
- The Contractor will immediately notify the BART Representative of any fires or other emergencies, who will then notify BART OCC. If the BART Representative is incapacitated, the HSR will notify BART OCC and 911 or BART Police. The work will be stopped and work area will be secured from any unauthorized individuals until emergency services arrive.
- These procedures may be amended, with concurrence from the Resident Engineer who will notify Operations Liaisons and the assigned BART Engineer, as needed to further the work and additionally safety requirements may be considered and implemented. The goal is to complete the work while ensuring the safety of BART patrons and employees and the integrity of the BART System.
- If patrons or pedestrians ask any questions, they will be referred to BART Community Relations. {*Contractor*} will not have any unauthorized communication with residents or patrons.

{Contractor to identify what could go wrong. Identify all likely hazards. What actions will be taken in the rare, extreme and/or unlikely event something does go wrong. What outside assistance might be necessary? Will this assistance be available if this situation occurs in the middle of the night?}

Examples include –

- *Should a Contractor notice any damage to the third-rail cover board, immediately notify the EIC who will inform the proper authorities.*
- *Contractor working in the Train Control Room noticing an unusual condition (e.g.: water, excessive heat, objects, etc.) shall immediately notify the EIC, who will notify OCC.*
- *Ensure that any items, including barriers, that have a potential to accidentally foul the trackway are secured prior to leaving the Jobsite each day. Should any items foul the trackway during the work shift, Contractor shall immediately notify the BART Representative.*
- *Man-Lift could tip over into the BART security fence. Solution – Before booming up to assist the crane with the column form, have machine pointed as shown on the drawings to prevent entering the BART security fence.*

* As applicable

VII. OWNER AND GENERAL CONTRACTOR INFORMATION

[OFFICE, 24-HOUR CONTACT, RESPONSE TIME]

Contractor:

Project Manager:	*[i.e. 24 hours, 2 hour response]*	*510-XXX-XXXX*
Project Superintendent:		*510-XXX-XXXX*
Health and Safety Representative:		*510-XXX-XXXX*

BART:

Project Manager:	
Resident Engineer:	
Operations Liaisons:	*510-464-4945*
Operations Control Center	*510-834-1297*
BART Police	*510-464-7000*
BART Police Watch Commander	*510-464-7020*

EMERGENCY SERVICES

BART Police	24-HR Emergency 510.464.7000
California Highway Patrol	24-Hr Emergency 911
***[Local]* Police**	Non-Emergency XXX.XXX.XXXX
***[Local*] Police**	Emergency XXX.XXX.XXXX
***[Local]* Fire Department**	24-HR Emergency XXX.XXX.XXXX or 911
Medical Clinic – *[Site Specific]*:	XXX.XXX.XXXX
Medical Hospital – *[Site Specific]*:	XXX.XXX.XXXX
BART Operations Control Center (OCC)	510.834.1297

* As applicable

VIII. DRAWINGS/ATTACHMENTS/CUT-SHEETS/PHOTOGRAPHS

[Emergency Flow Chart, pertinent drawings, attachments, cut-sheets and/or photographs that more fully explain the work that is to be accomplished or equipment that will be used. Drawings, attachments etc. should be referenced in document via number and/or page.]

IX. RETURN TO SERVICE PROTOCOL*

Fixed objects installed or altered within the Track Zone must be confirmed to be clear of the Dynamic Envelope and not in a proximity that they could be struck by a moving train or on-rail equipment and/or a threat to life/safety. The following Protocol is to be implemented to ensure clearance of the Dynamic Envelope when a fixed object is installed or modified.

1. The Resident Engineer (RE), BART Engineer or BART Project Manager will be immediately on site and available to supervise the Contractor for all installations of, or alterations to fixed objects within the Track Zone. The RE will remain on site immediately available until all inspections and/or clearance checks are reported complete and there is no detected or suspected threat to automatic train operations (ATO) and the integrity of revenue service is protected. In the rare, extreme or unlikely event there is a detected or suspected threat to automatic train operations and/or the integrity of revenue service, the fixed and/or altered item must be immediately removed or restored to its original condition, and the clearance protocol must be implemented.
2. The contractor will take measurements and confirm clearance of the Dynamic Envelope.
3. The RE will observe, duplicate and confirm the contractor's measurements and clearance of the "Dynamic Envelope."
4. The RE will implement the use of the BART Principal Track Engineer certified template to confirm the installed or altered fixed object is clear of the Dynamic Envelope.
5. The RE will call the Operations Control Center (OCC) and advise the Central Manager that a fixed object has been installed or altered, measurements have been taken and the area is clear and available for Automatic Train Operations (ATO). This does not release the RE or the Project from the responsibility of remaining on site, immediately available, until clearance has been validated and the Project is released by the OCC.
6. The EIC is to call the OCC and advise the Central Manager of the installation and/or alteration of a fixed object and its exact location and request a train inspection to validate clearance of the Dynamic Envelope
7. The EIC, RE, Contractor, and Project Inspector are to remain on site immediately available until clearance is validated by train inspection and all are released by the OCC.

* As applicable

Project/Contract Name
BART #: XXXX-XXXX
Attachment XX - Emergency Notification Flow Chart

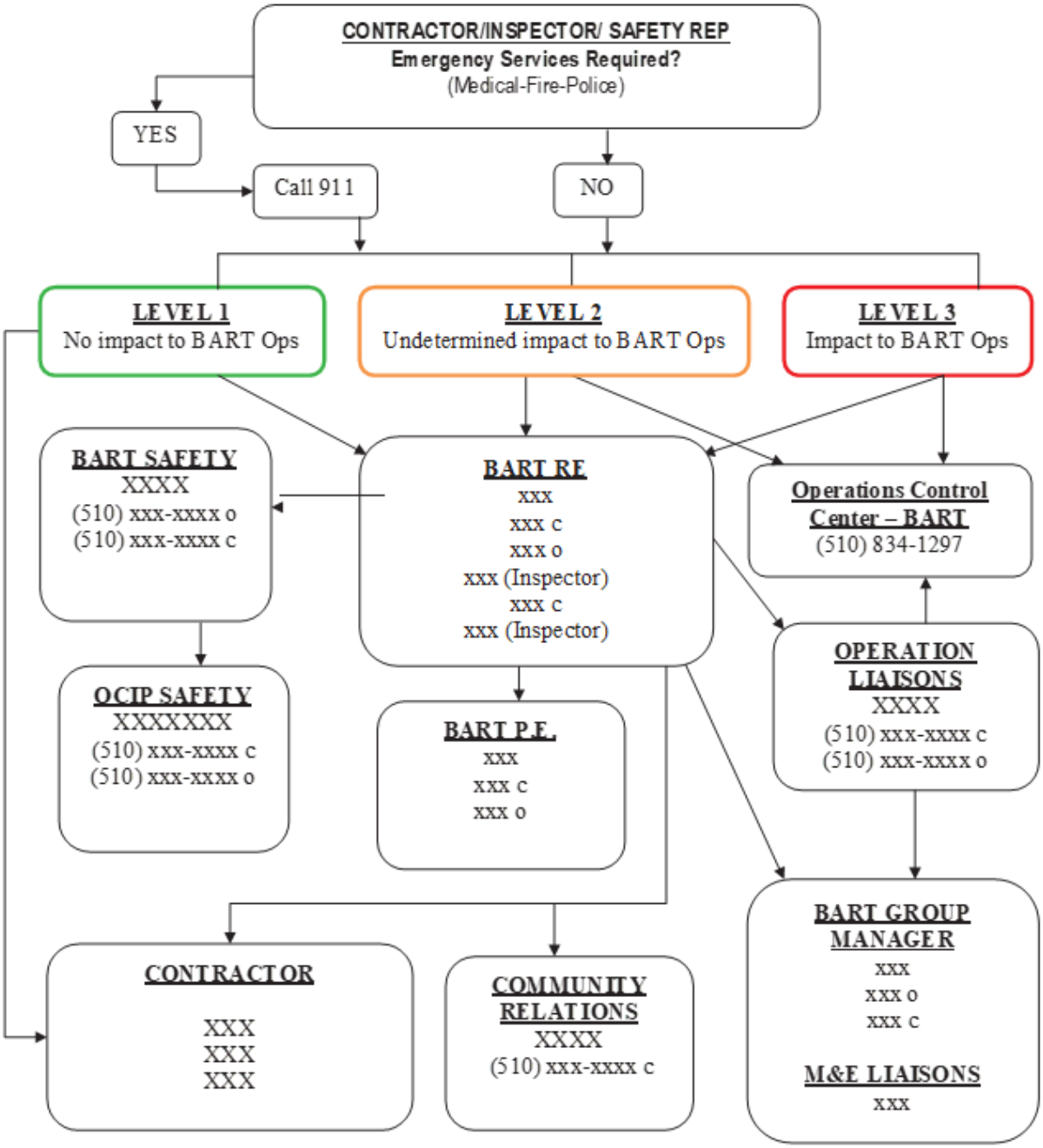


Figure 1: Emergency Notification Flow Chart

* As applicable

RETURN TO SERVICE CHECKLIST

(This form is to be completed for any type of work that may impact or cause intrusion in the Track Zone.)

At completion of work or portion of work identified within this SSWP, and prior to releasing the work area, the following list of activities and inspection points shall be performed by the Employee in Charge (EIC) to ensure a safe state of readiness for revenue operations. Enter time inspection activity is performed. Any planned or unplanned physical alteration to the existing infrastructure or variation to design shall be documented. The completed checklist shall be signed by the EIC that performed the inspection and forwarded to the Operations Control Center (Fax: 510-464-6751), at the earliest opportunity, before the end of the work shift.

Contract No. & Project Description: _____

Person in Charge & Contact No: _____

(As indicated on approved System Access Request form)

SSWP/IOP No.: _____

Inspection Date: _____

Inspected by (Print Name and Emp. ID No.): _____ **Title:** _____

Verification and/or activity:	**Time:**
1. Wayside/platform installation(s) secure from movement.	_____
2. Wayside/platform installation(s) clearance verified.	_____
3. Pre-inspection for restoration of Work Area for revenue service.	_____
4. Tools/materials removed from Work Area or properly secured.	_____
5. Final inspection of Work Area for return to service.	_____
6. Release Safe Clearance/Prohibit tags.	_____
7. All personnel clear of track.	_____
8. All access doors/gates secured.	_____
9. Release Work Area to proper jurisdiction.	_____
10. Contact OCC for Clearance Verification/Track Inspection (first train).	_____
11. All personnel released by OCC.	_____

12. Briefly describe any planned or unplanned physical alteration to infrastructure, work variations and/or any contingency plans implemented (use additional sheets as needed):

_____

_____

_____

_____

Signature: _____ **Date:** _____

* As applicable

ATTACHMENT 6:
EXAMPLE OF GLOBAL SITE SPECIFIC WORK PLAN

Company Logo or Name

GLOBAL SITE SPECIFIC WORK PLAN

Brief Description of Work *(e.g. Girder Shoring and Concrete Repair)*

CONTRACT NUMBER: _____

GSSWP # _____ REVISION #_____

CONTRACTOR NAME: _____

WORK DATES: _____

WORK LOCATION: _____

MEANS OF ACCESS TO WORK LOCATION: _____

WORK HOURS: Weekdays: _____

Saturday: _____ (if different)

Sunday: _____ (if different)

1. DESCRIPTION OF WORK:

Provide a 1-2 sentence description of the work to be accomplished under this GSSWP.

2. CONTINGENCY PLANS:

- Should any unauthorized person enter the site, they will be escorted out of the site and the BART Operations Control Center (OCC) or BART Police Department notified.
- Upon request by proper authority the OCC, BART Police Department, and/or the BART Safety Department, etc. the Contractor will stop work immediately. The Contractor will return the site to a safe condition expeditiously and vacate the area as quickly and as safely as possible, lending all reasonable support to the restoration of revenue service if so requested.
- If patrons or pedestrians ask any questions, they will be referred to BART Community Relations. {*Contractor*} will not have any unauthorized communication with residents or patrons.

{Contractor to identify what could go wrong. Identify all likely hazards. What actions will be taken in the rare, extreme and/or unlikely event something does go wrong. What outside assistance might be necessary? Will this assistance be available if this situation occurs in the middle of the night?}

Examples include:

- *If a fire starts within the work area, Contractor will take action to put out the fire per Safety Plan, notify local Fire Department, OCC, and the Engineer*
- *If a utility is struck, Contractor to notify OCC and the Engineer*

3. EMERGENCY CONTACTS *[24-HOUR CONTACT and RESPONSE TIME]*

CONTRACTOR:

- Project Manager: *[i.e. 24 hours, 2 hour response]* 510-XXX-XXXX
- Project Superintendent: 510-XXX-XXXX
- Health and Safety Representative: 510-XXX-XXXX

BART:

- Project Manager: *[i.e. 24 hours, 2 hour response]*
- Resident Engineer:
- Operations Liaisons:
- Operations Control Center 510-834-1297
- BART Police 510-464-7000
- BART Police Watch Commander 510-464-7020

SECTION 01 35 24

CONSTRUCTION SAFETY

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Contractor's Safety Program.

B. First Aid.

C. Emergencies and emergency procedures.

D. Protecting the general public.

E. Specific requirements.

F. Inspections by outside agencies.

G. Inspections by the District.

H. Hazardous materials encountered during construction.

1.02 RELATED SECTIONS

A. Section 01 35 14, Operating System Interface

B. Section 01 45 24, Testing Program Requirements

C. Section 01 57 00, Temporary Controls

1.03 MEASUREMENT AND PAYMENT

A. Separate measurement or payment shall not be made for work required under this Section. Costs in connection with the work specified herein shall be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work.

1.04 REFERENCES

A.	OSHA	Occupational Safety and Health Administration
B.	Cal/OSHA	California Occupational Safety and Health Administration
C.	CAMUTCD	State of California, Department of Transportation (Caltrans), California Manual on Uniform Traffic Control Devices
D.	ANSI	American National Standards Institute
E.	ASSE	American Society of Safety Engineers

1.05 SUBMITTALS

A. Refer to Section 01 33 00, Submittal Procedures, for submittal requirements and procedures.

B. Submit within seven Days of Notice to Proceed the following items. Submittals must be approved prior to any physical work on the Jobsite and prior to submitting first monthly progress payment.

1. Contractor's proposed Health and Safety Representative's (HSR's) resume, identifying his or her work experience and qualifications.

2. Contractor's proposed Assistant Health and Safety Representative's (AHSR's) resume.

3. Contractor's Safety Program.

4. Two copies of the Contractor's Site Specific Emergency Action Plan.

C. When public areas are affected, submit for review and approval plans in accordance with Section 01 57 00, Temporary Controls.

1.06 CONTRACTOR'S SAFETY PROGRAM

A. The Contractor and Sub-Contractor's Safety Programs shall include an Injury and Illness Prevention Program, along with Trade Specific Safety Programs, Hazard Communication Program which includes the United Nations Globally Harmonized System of Classification and Labeling of Chemicals (GHS), Disciplinary Program, and Heat Illness Prevention Program. The Contractor shall be responsible for ensuring Subcontractor safety compliance.

1. Injury and Illness Prevention Programs must meet the Cal/OSHA minimum requirements:

   a. Management commitment and assignment of responsibilities.
   b. Safety communication system with workers.
   c. System for assuring worker compliance with safe work practices.
   d. Scheduled inspections and evaluation system.
   e. Accident investigation.
   f. Procedures for correcting unsafe and unhealthy conditions.
   g. Safety and health training and instruction.
   h. Recordkeeping and documentation.

2. Trade Specific Safety Programs including, but not limited to:

   a. Lockout and Tagout.
   b. Respiratory Protection.

c. Fall Protection.

d. Welding, Cutting, Brazing, and Hot Work.

e. Excavation and Trenching.

f. Confined Space.

g. Lead and Asbestos with current licenses, permits, and training records.

h. Forklift operations.

i. Crane and derrick signaling and operation.

3. Hazard Communication with Globally Harmonized System (GHS) and Safety Data Sheets (SDS) included.

4. Disciplinary Program, a policy that prohibits rough or boisterous play and activity, gambling, the use of alcohol or drugs, and the possession of weapons on the Jobsite.

5. Heat Illness Prevention Program.

B. All elements of the Safety Program must be indexed.

1.07 HEALTH AND SAFETY REPRESENTATIVE (HSR)

A. HSR shall have a minimum of two years of qualified project safety experience on similar type construction projects that is representative of the planned construction activities, a current OSHA 30 Hour Construction Safety Training Certification (OSHA Card), and current First Aid/CPR certification. HSR responsibilities cannot be delegated to an office or staff employee. HSR will be responsible for identifying project construction health and safety concerns and expediting corrective action. HSR will manage and administer safety for all construction activities, as well as be responsible for overseeing and managing the Assistant Health and Safety Representative(s). HSR shall enforce and ensure that all safety and health construction safety requirements are implemented. HSR shall complete BART Training in accordance with Section 01 35 14, Operating System Interface.

B. Assistant Health and Safety Representative (AHSR) shall have the same qualifications and responsibilities as HSR, with the exception that AHSR does not have to be a full-time representative and may perform other construction work as long as the work allows to provide effective safety oversight at the assigned Jobsite location. AHSR shall be an additional safety representative under the supervision of the HSR at the Jobsite, when the HSR cannot be present at Jobsite locations to oversee multiple shifts, or multiple Jobsite locations. Each additional shift and each Jobsite location entrance, separated by more than one quarter of a mile, shall have an approved AHSR present for the full duration of the construction work at the assigned Jobsite location. The engineer may approve a distance greater than one-quarter mile.

C. The HSR shall, periodically, be present at the multiple shifts or Jobsite locations to monitor, train and manage the performance of the assigned AHSR. The HSR or AHSR shall be present at all times when work is performed at the Jobsite.

1.08 FIRST AID

A. Contractor shall provide a minimum of one person who has a valid certificate in First Aid/CPR training from the American Red Cross, or equivalent training, that can be verified by documentary evidence. This person shall be made available at the Jobsite, at all times, to render First Aid/CPR.

B. Contractor shall provide first aid kit(s) in a weatherproof container. The contents of the first aid kit shall be inspected regularly to ensure that the expended items are promptly replaced. The contents of the first aid kit shall be arranged to be quickly found and remain sanitary. First aid dressings shall be sterile in individually sealed packages for each item. The minimum first aid supplies shall be in accordance with Cal/OSHA Title 8, Section 1512 Emergency Medical Services.

C. Workers shall receive prompt first aid care when injured.

D. The HSR shall coordinate Contractor and Subcontractor injury reporting.

1.09 EMERGENCIES AND EMERGENCY PROCEDURES

A. Contractor shall develop a Site Specific Emergency Action Plan for any event that may occur for the following categories: fire; worker injury; property damage and damage to various utilities (such as, electrical, gas, sewage, water, telephone or public roadways); earthquake; public demonstrations; bomb threats; hazardous materials encountered; toxic spills; explosions; vehicular accidents; and other items, as applicable to the project.

B. The Site Specific Emergency Action Plan shall be in writing and shall cover those designated actions employers and employees must take to ensure worker safety.

C. At a minimum, the following shall be included in the Site Specific Emergency Action Plan:

1. Alarm system and worker notification of emergency.

2. Means of reporting fires and other emergencies.

3. Designated evacuation assembly area.

4. Evacuation procedures and emergency escape route assignments.

5. Procedures for workers who remain to operate critical plant operations before they evacuate.

6. Accounting method for workers after an emergency evacuation has been completed.

7. Rescue and medical duties for workers performing them.

8. Emergency Notification Flow Chart containing names, job titles, and contact information of persons who can be contacted. This must be posted at the Jobsite in a location clearly visible to all Jobsite personnel or made readily available.

9. Identification of persons responsible for making emergency calls (preferably the ranking supervisor present).

10. Emergency Procedures shall be kept current.

11. Site Specific Emergency Action Plan training shall be included in employee orientation and re-training shall be provided to all workers as the Site Specific Emergency Action Plan is updated.

D. Information and directions for Hospital and Occupational Clinic closest to the Jobsite, shall be posted at the Jobsite or made readily available.

E. Contractor shall inform the Engineer immediately, should an accident or incident occur.

F. Following an accident or incident, the Contractor shall:

1. Secure the area as expeditiously as possible.

2. Provide only those, authorized representatives of the District and specific governmental agencies, an account of the nature of the emergency. Questions from media personnel shall be referred to the Engineer.

3. Whenever the Contractor requires emergency services, such as ambulance, Fire Department or Police, the Contractor shall use the posted emergency numbers and also contact a District representative at: (510) 834-1297, BART Operations Control Center (OCC).

1.10 PROTECTING THE GENERAL PUBLIC

A. The Contractor shall take the necessary steps to prevent injury to the general public, BART employees, and BART patrons, or damage to public property. The public shall be considered as any persons not employed by the Contractor or its Subcontractors. The Contractor shall adhere to the following requirements:

1. ANSI/ASSE “Protection of the Public on or Adjacent to Construction Sites.” This standard provides the recommended elements and activities on construction projects to provide protection for the public.

2. Work shall be performed outside of the designated work area only when specifically stated in writing from the Engineer.

3. Necessary steps shall be taken to protect and maintain work areas that interface with public areas (sidewalks, station entrances, lobbies, corridors and aisles, stairways, escalators, elevators, station platforms, etc.).

4. All travel ways, access and egress points shall be maintained and clear of obstructions at all times.

5. Warning signs stating, “Construction Area Authorized Personnel Only” shall be conspicuously posted around the perimeter of each secured construction site to warn the public.

6. Warning signs shall be conspicuously positioned and a trained flag person shall be assigned when the Contractor’s material or equipment may be encountered by pedestrians or vehicles.

1.11 SPECIFIC REQUIREMENTS

A. Work Areas: The Contractor shall provide a safe work area. When unsafe conditions do exist, immediate abatement is required.

B. Work Practices: The Contractor shall be responsible for assuring that all workers work safely.

C. Daily “Tool Box” Meetings:

1. The Contractor shall conduct daily “Tool Box” meetings for all workers. The purpose of these meetings is to:

   a. Discuss observed accident trends and causes.

   b. Plan safety into the work activities.

   c. Take action to correct workers’ safety concerns.

   d. Review emergency procedures with workers.

   e. Review public protection for daily work activities.

   f. Review identified daily work hazards and hazard control methods.

2. Daily documented pre-shift inspection shall be completed by a trained Competent Person, as defined by OSHA. The identified hazards and hazard control methods shall be communicated to all workers involved prior to the start of work, requiring written acknowledgement from the workers.

3. These meetings shall be documented and include the date, subject line, notes, names, and signatures of attendees. Documentation shall be forwarded to the Engineer within one week of the meeting.

D. Accident and Incident Reports: Notify Engineer immediately of any injury, property damage, incident or near miss. Provide Engineer with copies of all accident and incident reports, including witness names and contact information, responding agencies and contact information, USA tickets, pictures, drawing, employee training records, corrective action, and all other supporting documentation within 24 hours of occurrence. Written reports shall be required for all injuries, property damage, and near misses using Unusual Occurrence Report (UOR) form furnished by the Engineer. The Engineer, at her or his discretion, may hold a Safety Stand Down after an accident prior to commencement of work after the incident.

E. Cal/OSHA Permit and Registration Requirements:

1. Each Contractor shall obtain relevant permits, licenses, and certificates pertinent to the safety of workers and operations in compliance with the applicable legal requirements. Copies of the documents shall be submitted to the Engineer.

2. Permits shall be available for review at the Jobsite upon request of the Engineer.

3. Contractors must obtain and post Cal/OSHA Activity Permits from the California Division of Occupational Safety and Health for the following:

   a. Erection or demolition of any building, falsework, scaffolding, or structure the equivalent of three stories or higher, or the equivalent height of 36 feet.

   b. Erection or dismantling of vertical shoring systems more than 3 stories high, or the equivalent height of 36 feet.

   c. Excavation Permits shall be required for excavations 5 feet or deeper.

   d. Performing any work related to hazardous materials.

   e. Use of fixed or mobile tower cranes.

F. Personal Protective Equipment (PPE): The Contractor's personnel, without exception, are required to wear certain PPE. All PPE must meet the requirements of BART, OSHA, ANSI, ASTM, NIOSH, and any other PPE regulating agency.

1. Hard hats and safety vests are mandatory and must be worn at all times within the Jobsite.

   a. BART hard hats worn within the BART Operating Envelope must meet current BART Technical Specifications. Minimum requirements:

Color:	BART approved high visibility yellow green
Shape:	Full Brim
Accessories:	Chin Strap
Reflectivity:	Reflective Strip
Class:	Class E Type 1 ANSI 289.1-2009

   b. BART safety vests worn within the BART Operating Envelope must meet current BART Technical Specifications. Minimum requirements:

Color:	Fluorescent Lime Yellow
Visibility:	Class 3 ANSI Standard
Reflectivity:	Level 2 ANSI Standard
Reflective Tape:	At least 2″ wide reflective tape sewn to vest on top of 4″ wide red/orange trim. (Two horizontal stripes around entire vest (torso), two vertical stripes at front of vest from shoulder to top of horizontal stripe, stripes encircling each sleeve, and "X" stripe pattern on back of vest from shoulder to top of horizontal stripe)
Pockets:	One clear plastic pocket with flap (3.75″ H x 4.5″ W) on the front for ID Card.

c. All safety vests shall be made of high visibility fluorescent material. Vests must have one clear pocket with flap (3.75″ H x 4.5″ W) on the front for ID Card.

d. Safety vests and personal protective equipment must meet OSHA and CAMUTCD requirements when flagging or working on roadways.

2. Hearing protection mandatory in all operations where workers are exposed to 80 decibels or higher.

3. Eye protection mandatory at all times when on construction site. When performing tasks that produce flying debris or when handling any chemicals, appropriate eye protection shall be selected for the hazard or as specified in SDS.

4. Fall protection shall be worn and used when working above a potential hazard or a fall hazard greater than 6 feet.

5. Protective Footwear – work boots shall be required at all times on the Jobsite. Work boots shall comply with the American Society for Testing and Materials (ASTM) standard ASTM F-2413. Work boots with visible damage will not be permitted.

6. Clothing – only long pants and shirts with sleeves allowed. No tank tops, mesh or flammable clothing will be permitted.

7. Respiratory protection – when required by law to protect workers from breathing contaminated and oxygen-deficient air when effective engineering controls are not adequate, or while engineering controls are being instituted.

G. Safety Administration Requirements:

1. Daily documented Jobsite pre-shift inspections.

2. Daily documented pre-shift equipment inspections shall be completed prior to use. Inspections shall be completed by a trained person.

3. Daily documented pre-shift inspections shall be performed by a Competent Person for excavation and trenching operations.

4. Daily documented scaffold inspections shall be performed by a Competent Person prior to use.

5. Monthly documented fire extinguisher inspections are required. Inspections shall be completed by a trained Competent Person.

6. Hot Work Permits shall be required for all hot work. A trained Fire Watch shall be required during work and for a minimum of 30 minutes following hot work activities.

7. OSHA and BART training requirements apply; workers shall be trained to perform their work tasks. The Contractor shall provide Site Specific New Hire

Orientation to all workers, including Subcontractors. Site Specific New Hire Orientation shall be required annually. All training shall be documented. When requested, employee training documentation shall be made available for review.

8. Site Specific New Hire Orientation shall include, at a minimum, review of Contractor Safety Program, Site Specific Emergency Action Plan, Personal Protective Equipment, and Fall Protection.

9. Safety Data Sheets (SDS) shall be maintained with the chemicals and consumable products on site and made available upon request. Chemicals and consumable products turned over to the District should be accompanied by the SDS.

10. Maintain Safety Programs to meet current regulatory agency requirements.

11. Contractor shall review Subcontractors' Safety Programs to ensure that they meet the same requirements as the Contractor Safety Program including Subcontractor trade specific programs.

12. Conflict between Codes and Safety Standards: In the case of conflict between codes, safety standards, reference standards, drawings, and other contract documents, the most stringent requirements shall govern. Conflicts shall be immediately brought to the attention of the Engineer. BART reserves the right to issue a final determination for conflicts.

1.12 INSPECTIONS BY OUTSIDE AGENCIES

A. The Contractor shall be subject to inspections by outside agencies, including, but not limited to Cal/OSHA. The Contractor shall notify the Engineer immediately should citations, warnings or safety violations be issued. Copies of same shall be provided to the Engineer within 48 hours.

1.13 INSPECTIONS BY THE DISTRICT

A. The Contractor shall cooperate with designated District representatives when conducting site inspections.

B. The District may periodically make quality assurance audits of the Contractor's Safety Program.

1.14 CONSTRUCTION HAZARDS

A. Temporary Fencing: Refer to Specification 01 52 00, Construction Facilities.

B. Hazard Warning Signs: Signs and symbols shall be visible at all times when work is being performed, and shall be removed or covered promptly when the hazards no longer exist.

C. Secure Work Areas: Secure work areas at all times to prevent unauthorized access.

D. Gates: Secure gates with a chain and tamper proof lock in an open or closed position to prevent from accidental swinging.

E. Traffic Control: Approved traffic controls shall be inspected daily to ensure compliance.

F. Flaggers: All flaggers must have current CAMUTCD, OSHA and Caltrans approved flagger training certification when directing traffic.

G. All mobile equipment shall have a functioning backup alarm or a spotter when the vehicle is backing up or when views are obstructed.

H. Pedestrian Control: Pedestrians must be able to see and understand the routes they are to follow.

I. Scaffolds: Scaffolds shall be erected, moved, dismantled, or altered only under the supervision and direction of a Competent Person qualified in scaffold erection, moving, dismantling or alteration. Such activities shall be performed only by experienced and trained person selected for such work by the Competent Person.

J. Lockout and Tagout:

1. The Contractor must properly lockout and tagout any equipment within the Contractors responsibility.

2. Control of the lock and tag is also the Contractor’s workers’ responsibility.

3. The Contractor shall coordinate instances that require multi-employer lockout and tagout activities.

K. Ground Fault Circuit Interrupters (GFCIs):

1. Shall be used for temporary electrical wiring cords and equipment.

2. GFCIs shall be tested in accordance with the manufacturers' requirements and tested daily prior to use.

3. STOP WORK for GFCI trips and immediately notify the Engineer for further direction. Inspect equipment for defects and confirm with manufacturer that there are no recalls.

L. Dust and Silica Control: Workers and the public shall be protected from respirable crystalline silica exposures by using dust controls and personal protective equipment.

M. Respiratory Protection: When air is contaminated above the Permissible Exposure Level (PEL) including harmful dusts, fogs, fumes, mists, gases, smokes, sprays, or vapors, appropriate respirators shall be provided to each potentially exposed worker as required per OSHA 1926.103.

N. Tools and Equipment: When using tools and equipment, follow manufacturer’s instructions.

O. Transporting Materials in Public Areas: Travel ways, access, and egress points shall be maintained and clear of obstructions, in order to prevent slips, trips, and falls. When transporting material in public areas a spotter(s) shall be required. A temporary barricade system shall also be required when needed and requested by the Engineer. All ground and floor openings shall be covered, secured, and properly marked. No materials may be transported on public elevators or escalators.

P. Mobile Equipment: Current training documentation shall be made available when requested. Retraining shall be required following all near misses, accident, or when requested.

Q. Confined Space: Precautions shall be taken when workers enter a confined space. These precautions include current written confined space program, current documented training that meets OSHA requirements, confined space permit that includes rescue plan.

R. Excavation: Elements of the OSHA Trenching and Excavation Standards shall apply. OSHA Excavation Permits shall be required for excavations 5′ or deeper. At least one Trenching and Excavation Competent Person, with current OSHA certification certificate must be present at all times during trenching and excavation activities.

S. Fall Protection: Elements of the BART and OSHA Standards shall apply. Fall protection shall also be required when requested by the Engineer. The most stringent requirements shall govern.

T. Fire Extinguishers: Fire extinguishers not less than 5 lbs. each shall be made available. A hazard assessment shall be required in order to determine potential hazards that exist and the types of firefighting equipment that shall be necessary for each construction area.

U. Fire extinguishers shall be kept in close proximity to locations where fuel is used.

V. “No Smoking” Signs: Signs shall be posted at fuel storage areas.

W. Smoking: Smoking shall be permitted only in designated areas approved by the Engineer.

X. Hot Work:

1. Hot work includes, but is not limited to, the following activities: grinding, cutting, welding, brazing or soldering, heating, hot air welding or other operations that generate heat, flames, arcs, sparks or other sources of ignition. Prior to performing hot work, the Contractor shall evaluate the following: type of hot work to be performed, site preparation, atmospheric conditions, and use of appropriate personal protective equipment, and firefighting equipment.

2. Site preparation shall include a survey for the following: combustible materials; hazards posed by heat transfer; flammable, corrosive, or toxic residues; and equipment linings. Items like ones listed above shall be removed or protected from hot work activities prior to the start of work. Hole openings that sparks may enter through shall be secured prior to hot work operations.

3. The Contractor shall also evaluate the work area for the potential consequences of thermal conduction. Thermal conduction is the transfer of heat that could cause ignition by or through an object heated by the hot work operation.

4. A Hot Work Permit system shall be established and implemented.

Y. The use of a secondary containment sufficient to catch any contaminant or fuel releases that may occur shall be required around stationary equipment or fuel cans.

PART 2 – PRODUCTS

Not Used

PART 3 – EXECUTION

Not Used

END OF SECTION 01 35 24

SECTION 01 35 33

SECURITY PROCEDURES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. This Section describes the security requirements for high risk projects to reduce the risk of theft and vandalism to District and Contractor property.

1.02 RELATED SECTIONS

A. Project progress schedules and status reports are specified in Section 01 32 16, Construction Progress Schedules.

B. Section 01 33 00, Submittal Procedures.

C. Section 01 35 54, Identification and Security.

D. Section 01 52 00, Construction Facilities.

E. Section 01 60 00, Product Requirements.

F. Section 01 74 14, Cleaning.

1.03 MEASUREMENT AND PAYMENT

A. Separate measurement or payment will not be made for work required under this Section. All costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work.

1.04 SUBMITTAL REQUIREMENTS

A. Schedule of Submittals: Within thirty calendar Days after the effective date of Notice to Proceed or before start of Work at the Jobsite, whichever occurs first, the Contractor shall submit for the Engineer's review and approval, as follows:

1. Contractor shall provide a security plan to BART Police via the Engineer at the start of Work to establish necessary coordination between BART Police and Projects. The security plan shall include a definition of work, list of employees and subcontractor employees that will be on the Jobsite, a list of contact numbers and security measures that the Contractor intends to take during the Work. BART Police and Engineer will sign off on the security plan. Correspondence shall continue with BART Police on a need by need basis until the Acceptance of Work. The Contractor shall maintain and submit the security plan on a monthly or as needed basis for approval as determined by the Engineer.

2. The Contractor shall provide the Engineer with an inventory of assets that will be stored at the Jobsite. Project assets include tools, machines, vehicles, and construction materials of value. Asset inventory shall include the cost of asset, serial numbers or other unique identifiers, photographs, replacement costs, planned storage locations and the quantity of materials stored at Jobsite. The Contractor shall provide updates as major inventory changes occur or as requested by the Engineer.

1.05 CONTRACTOR'S RESPONSIBILITIES

A. The Contractor shall prepare and maintain a weekly written roster of all personnel, including subcontractors that are performing work on the Jobsite. The Contractor shall be prepared to provide updated rosters to Engineer or BART Police upon request.

B. Contractor shall report crime and attempted crime that occurs within Work area to BART Police immediately. Initial correspondence shall be made through the BART Police Dispatch Office at (510) 464-7000. A follow-up report shall be made to the Engineer. Contractor and subcontractors employees shall cooperate with BART Police during an investigation.

C. If criminal acts persist or if risk is deemed high enough as determined by the Engineer, a survey of the Jobsite shall be jointly conducted by BART Police, Engineer, and the Contractor to identify existing threats to Jobsite security. BART Police shall provide the Engineer and Contractor with a set of written or verbal recommendations based on the threat assessment. The Contractor shall put in a good faith effort in implementing BART Police recommendations. If recommendations are not followed and criminal activity persists, the District will assess liquidated damage as specified in Contract Specifications Section 01 11 00, Summary of Work.

D. When the Contractor is not present or performing Work, no assets (regardless of value) shall be left unsecured at the Jobsite. Materials vulnerable to theft, such as cables, tools and equipment, shall be secured in a locked storage facility. Daily removal of scrap material shall be performed.

E. A locked, physical perimeter shall be established around the storage area. The Contractor shall post Project Name and after hours contact information in such a manner as to be plainly visible from inside and outside of the construction area.

F. Entry doors to storage areas and fenced gates shall be properly secured with a high grade, anti-cut lock. During nonbusiness hours, heavy equipment shall be disabled to prevent unauthorized use and, if applicable, shall be parked in front of the doors of temporary storage containers to serve as a barricade.

G. If criminal activity persists or if risk is deemed high enough, the Engineer at the Engineer's discretion may direct the Contractor to hire private security or implement electronic surveillance or both at no additional cost to the District.

1.06 PRIVATE SECURTY

A. If private security forces are provided due to high risk or repeated incidents, the Contractor shall provide security services that comply with the following requirements.

1. Security guards shall be employed by licensed private patrol operators.

2. The Contractor through the Engineer shall provide BART Police with the company name, contact information and the specific date, time and location of private patrols.

3. Private Security Patrols shall adhere to BART Police Officers' Association standard, which may allow private security tasks to be performed on BART property. Contactor shall patrol areas designated as property controlled or owned by the Contractor.

4. Security guards shall be in uniform and drive a marked company vehicle while on patrol.

5. Security guards shall possess a valid security guard registration and carry it with them at all times while on duty.

PART 2 – PRODUCTS

2.01 ELECTRONIC SURVEILLANCE

A. If electronic surveillance is provided due to high risk or repeated incidents, the Contractor shall provide electronic surveillance that meets the following requirements.

1. The electronic surveillance equipment shall be a mobile surveillance unit (MSU) consisting of multiple cameras as required to provide video coverage of vulnerable areas of the Jobsite.

2. Cameras shall be high resolution (minimum 720p), color, and low light cameras.

3. Upon detection of any movement, a remote alarm shall be generated and video shall be recorded until movement has ceased. The video shall be retained for a minimum of seven Days. Recorded video and related information shall be provided to BART Police upon request.

4. The MSU alarm shall be live off-site monitored 24 hours per Day, seven Days a week. Any movement shall be promptly evaluated and if appropriate, result in prompt notification of the BART police.

5. The MSU shall be self-powered or Contractor shall provide the necessary power.

6. The electronic surveillance equipment shall remain the property of the Contractor and shall be removed when no longer needed as determined by the Engineer.

PART 3 – EXECUTION

Not Used

END OF SECTION 01 35 33

SECTION 01 35 54

IDENTIFICATION AND SECURITY

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Identification and security requirements applicable to the Contractor's work within the Operating System as defined in Section 01 35 14, Operating System Interface, and non-public areas.

B. For Security Sensitive Information (SSI) contracts additional security and identification procedures are required.

1.02 MEASUREMENT AND PAYMENT

A. Separate measurement or payment will not be made for work required under this Section. All costs in connection with the worked specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work.

1.03 IDENTIFICATION

A. Within seven Days of the date of Notice to Proceed for this Contract, the Contractor shall submit a list of all employees of the Contractor and all employees of Subcontractors who may perform work on this Contract. The Engineer will contact the Contractor within seven Days from submission to schedule an appointment with the BART Police Department for those individuals requiring the Contractor Photo ID badges as specified in this Section. The Contractor shall make an appointment date for all such individuals that is no more than seven Days from the date of the Engineer's notification. Should the Contractor subsequently request additional identification badges for personnel not on the original list, the Contractor is cautioned that such badges may take up to 60 Days to be approved. The Contractor shall not be entitled to any claim for additional compensation, damages, or schedule extension that may result from the failure of personnel to receive timely security clearances.

1. Badges will not be required for nor issued to truck drivers delivering material or performing other trucking activities that require them to stay with their vehicle at all times.

B. Contractor and Subcontractors personnel shall prominently display a valid, original District-issued identification badge while accessing and while performing work in areas in the Operating System and non-public areas whether part of the Operating System or elsewhere. Contractor and Subcontractor personnel are not allowed to perform work in these areas until all of the required identification, security, and background checks have been completed.

C. The badge shall be clearly displayed and not obscured by any clothing or personal effects. Badges shall not be duplicated.

D. The badge does not entitle the holder to transportation without charge on the BART System.

E. The District issues two types of identification for construction contractors:

1. Contractor Photo ID Badge: Contractor Photo ID Badges are required for Contractors and Subcontractors working on District property for a period exceeding two weeks. The badge contains the individual's name, photograph, contract number, work location and expiration date.

2. Short Term Worker Identification Badge (C Badge): C Badges are required for Contractors and Subcontractors assigned to a specific work site for a limited time period not to exceed two weeks within a 90 Day period. The badge contains a large black "C" on the face of the card, the contract number, expiration date, and serial number. There is no photograph on the C Badge.

1.04 IDENTIFICATION, SECURITY, AND BACKGROUND CHECKS

A. Contractor shall ensure that individuals requiring Contractor Photo ID badges report to the designated BART Police office for processing at their scheduled appointment time. Individuals requiring Contractor Photo ID badges are subject to the following identification, security, and background checks:

1. Individuals shall provide valid and current photo identification, such as a California Driver's License, a California Identification Card, a U.S. Passport, or documentation from the U.S. Citizenship and Immigration Services (a Work Permit or an Alien Registration Card [Green Card]).

2. The individual's photo identification will be matched against the Contractor's list of employees authorized to work on a particular job.

3. The individual's identification will be matched against the FBI Watch List.

4. The individual shall undergo a criminal history check administered through the BART Police Department (BPD). BPD will collect a set of fingerprint samples from the individual. The samples will be compared with the State of California's Department of Justice (DOJ) Criminal Offender Records System. Upon receipt of DOJ's response, BPD will notify the Engineer and appropriate departments of the results of the background check. DOJ records will be maintained by BPD and kept confidential to the extent permitted by law.

B. Individuals requiring C Badges are subject to the following identification, security, and background checks:

1. Individuals shall provide valid and current photo identification, such as a California Driver's License, a California Identification Card, a U.S. Passport, or documentation from the U.S. Citizenship and Immigration Services (a Work Permit or an Alien Registration Card [Green Card]).

2. The individual's photo identification will be matched against the Contractor's list of employees authorized to work on a particular job.

3. The individual's identification will be matched against the FBI Watch List.

1.05 ADMINISTRATION

A. General

1. Badges will remain the property of the District and the privileges of use may be revoked as a result of invalidation, expiration, or confiscation.

2. The Contractor shall immediately notify the Engineer of any lost or stolen badges. A fee of $100 will be charged for a replacement badge.

3. Stolen Badges: Upon receipt of a copy of an official police report on the loss by theft or robbery of a badge, a replacement badge will be issued as expeditiously as possible.

4. The Contractor shall return issued badge to the Engineer upon termination of Contractor or Subcontractor employee or expiration of badge. The Contractor shall return all issued badges to the Engineer upon completion of the Contract.

B. Daily Badge Administration:

1. The Contractor shall collect the badges daily until completion of the Contract.

2. The Contractor shall maintain an accurate and up-to-date list of individuals to whom badges have been issued. The list shall contain the name of each individual and the serial number of the badge. The Engineer will periodically check the Contractor's records to ensure accurate record keeping and tracking of badges.

3. Prior to the start of work each day, the Engineer will check the badges of all workers.

1.06 NONCONFORMANCE

A. The absence of a valid Badge may be grounds for removal from District property. Such removal will not be grounds for any time extension or additional compensation.

B. Failure to adhere to the requirements of this Section shall be grounds for revocation of badge privileges. The badge shall be surrendered to the Engineer for closer inspection or confiscation as required.

PART 2 – PRODUCTS

Not Used

PART 3 – EXECUTION

Not Used

END OF SECTION 01 35 54

SECTION 01 42 19

REFERENCE STANDARDS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Reference standard file

B. Abbreviations

1.02 MEASUREMENT AND PAYMENT

A. Separate measurement or payment will not be made for work required under this Section. All costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work.

1.03 REFERENCE STANDARDS

A. The Contract Documents contain references to various standard specifications, codes, practices, and requirements for materials, equipment, work quality, installation, inspections, and tests, which references are published and issued by the organizations, societies, and associations listed herein by abbreviation and name. Such references are hereby made a part of the Contract Documents to the extent specified in General Conditions Article GC1.5.

B. Whenever a referenced standard contains administrative requirements, including measurement and payment provisions, such as the standard specifications of various government entities, utility districts, and other agencies, such administrative requirements shall not apply to the Work of this Contract. References to such standards shall be applicable to the pertinent technical provisions only.

1.04 REFERENCED STANDARDS FILE

A. Referenced standards shall be obtained by the Contractor and maintained in the Contractor's office. Referenced standards shall be made readily available for use by the Engineer and the Contractor’s staff in carrying out the quality assurance and quality control programs specified in the Contract Documents, and to assure compliance with the requirements of the codes, specifications, test methods, practices, and other standards referenced in the Contract Documents.

1.05 ABBREVIATIONS

A. Wherever in the Contract Documents an organization’s abbreviation or acronym is used, it shall be understood to mean the full name of the respective organization as specified in General Conditions Article GC1.2, as specified in the various Specification Sections, and as follows:

1.	AA	Aluminum Association
2.	AABC	Associated Air Balance Council
3.	AAMA	American Architectural Manufacturers Association
4.	AAN	American Association of Nurserymen
5.	AAR	Association of American Railroads
6.	AASHTO	American Association of State Highway and Transportation Officials
7.	ACI	American Concrete Institute
8.	AEIC	Association of Edison Illuminating Companies
9.	AFBMA	Anti-Friction Bearing Manufacturer's Association
10.	AIMA	Acoustical and Insulating Materials Institute
11.	AISC	American Institute of Steel Construction
12.	AISI	American Iron and Steel Institute
13.	AMCA	Air Moving and Conditioning Association
14.	ANSI	American National Standards Institute
15.	APA	American Plywood Association
16.	API	American Petroleum Institute
17.	APTA	American Public Transportation Association
18.	AREMA	American Railway Engineering and Maintenance-of-Way Association
19.	ARI	Air-conditioning and Refrigeration Institute
20.	ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc.
21.	ASME	American Society of Mechanical Engineers
22.	ASNT	American Society for Non-destructive Testing
23.	ASQC	American Society for Quality Control
24.	ASTM	American Society for Testing and Materials
25.	AWPA	American Wood Preservers Association

26.	AWPI	American Wood Preservers Institute
27.	AWS	American Welding Society
28.	AWWA	American Water Works Association
29.	BAAQMD	Bay Area Air Quality Management District
30.	BHMA	Builders' Hardware Manufacturers Association
31.	BSI	Building Stone Institute
32.	Caltrans	State of California, Department of Transportation
33.	CARB	California Air Resources Board
34.	CEQA	California Environmental Quality Act
35.	CLFMI	Chain Link Fence Manufacturers Institute
36.	CMAA	Crane Manufacturer’s Association of America
37.	CPUC	California Public Utilities Commission
38.	CRSI	Concrete Reinforcing Steel Institute
39.	CS	Commercial Standards, United States Department of Commerce
40.	DEMA	Diesel Engine Manufacturer’s Association
41.	DHI	Door and Hardware Institute
42.	DOT	United States Department of Transportation
43.	DSI	Dimensional Stone Institute
44.	DTSC	California Department of Toxic Substances Control
45.	EEI	Edison Electric Institute
46.	EIA	Electronic Industries Association
47.	FGMA	Flat Glass Marketing Association
48.	FM	Factory Mutual System
49.	FS	Federal Specification
50.	FTA	Federal Transit Administration
51.	ICBO	International Conference of Building Officials

52.	ICEA	Insulated Cable Engineers Association
53.	IEEE	Institute of Electrical and Electronics Engineers
54.	IES	Illuminating Engineering Society
55.	IMSA	International Municipal Signal Association
56.	IPCEA	Insulated Power Cable Engineers Association
57.	ITE	Institute of Traffic Engineers
58.	JIC	Joint Industrial Council
59.	MIA	Marble Institute of America
60.	MSS	Manufacturers Standardization Society
61.	NAAMM	National Association of Architectural Metal Manufacturers
62.	NBFU	National Board of Fire Underwriters
63.	NEBB	National Environmental Balancing Bureau
64.	NEC	National Electrical Code
65.	NEII	National Elevator Industry, Inc.
66.	NEMA	National Electrical Manufacturers Association
67.	NFPA	National Fire Protection Association
68.	NLMA	National Lumber Manufacturers' Association
69.	NRCA	National Roofing Contractors Association
70.	NTMA	National Terrazzo and Mosaic Association
71.	PCA	Portland Cement Association
72.	PCI	Precast/Prestressed Concrete Institute
73.	PDI	Plumbing and Drainage Institute
74.	PEI	Porcelain Enamel Institute
75.	PG&E	Pacific Gas and Electric Company
76.	PS	U. S. Product Standard
77.	SMACNA	Sheet Metal and Air Conditioning Contractors National Association, Inc.

78.	SSPC	Steel Structures Painting Council
79.	SWI	Sealant and Waterproofers Institute
80.	TCA	Tile Council of America
81.	UBC	Uniform Building Code of the International Conference of Building Officials
82.	UL	Underwriters Laboratories Inc.
83.	UMC	Uniform Mechanical Code
84.	UPC	Uniform Plumbing Code
85.	USBPR	United States Bureau of Public Roads
86.	WCLA	West Coast Lumbermen's Association
87.	WCLIB	West Coast Lumber Inspection Bureau
88.	WH	Warnock Hersey
89.	WIC	Woodwork Institute of California

PART 2 – PRODUCTS

Not Used

PART 3 – EXECUTION

Not Used

END OF SECTION 01 42 19

SECTION 01 43 00

QUALITY ASSURANCE

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Contractor's construction quality plan.

B. Contractor's quality control representative.

1.02 RELATED SECTIONS

A. Field samples and site mockups are specified in Section 01 43 38, Field Samples and Mockups.

1.03 MEASUREMENT AND PAYMENT

A. Separate measurement or payment will not be made for work required under this Section. All costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work.

1.04 SUBMITTALS

A. Construction Quality Plan: Submit the Contractor's proposed Construction Quality Plan not later than 14 Days after the effective date of the Notice to Proceed. The Contractor's Construction Quality Plan will be reviewed by the Engineer, who will provide comments to the Contractor within 20 Days after its submittal. The Contractor shall revise its plan in accordance with the review comments and resubmit as required. The Contractor shall perform the Work in accordance with the approved plan.

1. In the event that the Contractor chooses to schedule activities prior to the approval of the Construction Quality Plan, the Contractor shall submit interim Quality Plans for such activities to the Engineer for approval. The activities addressed in such Quality Plans may not be started until the appropriate Quality Plan has been approved by the Engineer. Such plans shall be incorporated later into the overall Construction Quality Plan.

B. Construction Quality Control Representative: Submit to the Engineer for approval, within ten Days after the effective date of the Notice to Proceed, the name, qualifications, experience, and resume of the contractor's proposed Construction Quality Representative as specified in Article 1.06 herein.

C. Quality Control Testing Firm: The Contractor shall submit the name, address, and qualification, together with the scope of proposed services, of the proposed testing firm to the Engineer for approval as least 30 Days prior to the scheduled commencement of any work involving such testing. Should the Contractor desire to

use more than one firm for quality control testing, the required information shall be submitted for each such proposed firm.

1.05 CONTRACTOR'S CONTRUCTION QUILITY PLAN

A. The Contractor shall prepare a Construction Quality Plan which shall identify the Contract quality requirements for each activity and describe how the Contractor intends to furnish that quality, including control testing, certification, and records which the Contractor intends to provide.

B. The Construction Quality Plan shall include, but not be limited to, the following elements:

1. Training of personnel;
2. Installation, inspection, examination, and test control;
3. Control of measuring and test equipment;
4. Material control;
5. Control of non-conforming items;
6. Subcontractor controls;
7. Supplier and vendor controls:
8. Documentation and records control;
9. Special process control, and
10. Facility turnover.
11. Test Program Plan.

C. Test Program Plan:

1. A Test Program Plan shall be prepared, identifying the approach for accomplishing each of the specified tests. A narrative shall be prepared for each test specified, describing the test set-up, equipment, and instrumentation that will be used; procedure to be implemented; and the anticipated, as well as acceptable, test results. Drawings showing the relationship of the test sample and all significant components of the test equipment shall be included, as necessary, to describe the test set-up and procedure. The Test Program Plan shall include the test sequencing.

2. Equipment specifications and calibration methods for all testing equipment shall be included in the Test Program Plan.

3. Identity and qualifications of personnel who will perform testing shall be included in the Test Program Plan.

4. The Test Program Plan shall include the proposed format for reporting test data.

5. The projected schedule for test procedure submittals, test executions, and test results report submittals shall be included in the Test Program Plan.

6. After approval of the Test Program Plan, any proposed changes will require approval of the Engineer prior to implementing the change.

1.06 CONTRACTOR'S QUALITY CONTROL REPESENTIVE

A. The Contractor shall assign a Quality Control Representative to monitor the quality of construction activities.

B. In addition to persons performing or directly supervising the Work, the Contractor shall use qualified persons for quality verification and audits. These employees shall not be part of the production staff nor subject to the authority of the production staff, and shall have the necessary authority to perform their roles effectively.

C. The Contractor shall define the responsibility and authority of personnel primarily responsible for performing quality verification and audits. Include responsibility and authority to perform the following:

1. Identify and record nonconforming items or conditions;

2. Initiate and recommend correction through appropriate channels;

3. Verify correction or implementation of solutions to correct nonconforming items or conditions; and

4. Prevent or control further nonconformance.

PART 2 – PRODUCTS

Not Used

PART 3 – EXECUTION

Not Used

END OF SECTION 01 43 00

SECTION 01 43 38

FIELD SAMPLES AND MOCK-UPS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Field samples and mock-ups.

1.02 MEASUREMENT AND PAYMENT

A. Separate measurement or payment will not be made for work required under this Section. All costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work.

1.03 FIELD SAMPLES AND MOCK-UPS

A. Field samples and mock-ups shall be prepared at the jobsite by the Contractor as specified in the various Sections of these Specifications. Affected finish work shall not be started until the Engineer has approved the field samples and jobsite mock-ups in writing.

B. Construct and prepare field samples and jobsite mock-ups at designated locations at the jobsite or on the structure as directed by the Engineer.

1. The Contractor shall have product manufacturers inspect and approve field samples and mock-ups, that involve their materials, for proper application or installation of the materials in accordance with their respective instructions and recommendations for the conditions or circumstances involved in the application or installation.

2. The Contractor shall make arrangements with the respective product manufacturers to provide job or field service as specified in Section 01 43 00, Quality Assurance.

C. Construct or prepare as many additional samples and mock-ups as may be required, as determined by the Engineer, until desired features, textures, finishes, and colors are obtained. Approved samples and mock-ups shall serve as the standards of quality for the various affected units of work.

D. Preserve approved field samples and mock-ups for comparison purposes until the affected work is completed and accepted by the District. Finished work shall match the approved field samples and mock-ups.

1.04 NONCONFORMANCE

A. Completed work that does not exactly match approved field samples and mock-ups will be rejected, and shall be replaced with work that does exactly match the approved field samples and mock-ups at the Contractor's expense.

B. If the Contractor elects to start work before the Engineer has approved the related field samples or mock-ups, the Contractor does so at the risk of having the work rejected by the Engineer without compensation.

1.05 REMOVAL AFTER COMPLETION

A. Field samples and mock-ups shall be removed from the jobsite and structures after completion and acceptance of the affected work or otherwise as directed by the Engineer.

PART 2 – PRODUCTS

Not Used

PART 3 – EXECUTION

Not Used

END OF SECTION 01 43 38

SECTION 01 45 00

QUALITY CONTROL

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Source of materials.

B. Work quality.

C. Manufacturer's specifications and instructions.

D. Specialist applications/installer.

E. Manufacturer's field services.

F. Finish tolerances.

G. Engineer's monitoring.

H. Engineer's inspections and tests.

I. Contractor's quality testing.

J. Test reports.

K. Quality control audits.

L. Certificates of compliance.

M. Special inspections.

1.02 MEASUREMENT AND PAYMENT

A. Separate measurement or payment will not be made for work required under this Section. All costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work.

1.03 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, for submittal requirements and procedures.

B. Within five Days after completion of testing performed by or for the contractor, submit test results of such tests to the Engineer. Identify test reports with the information specified for submittals in Section 01 33 00, Submittal Procedures, and additionally, the name and address of the organization performing the test, and the date of the tests.

1.04 SOURCE OF MATERIALS

A. In accordance with Section 01 33 23 - Shop Drawings, Product Data, and Samples, the Contractor shall notify the Engineer in writing of the sources from which the Contractor proposes to obtain materials requiring District approval, certification, or testing.

1.05 WORK QUALITY

A. Shop and field work shall be performed by mechanics, crafts-persons, artisans, and workers skilled and experienced in the fabrication and installations of the work involved. The work shall be performed in accordance with the Contract Documents and the reviewed and accepted Shop Drawings.

B. Work shall be erected and installed plumb, level, square, and true, or true to indicated angle, and in proper alignment and relationship to the work of other trades. Finished Work shall be free from defects and damage.

1.06 MANUFACTURER'S SPECIFICATIONS AND INSTRUCTIONS

A. Unless otherwise indicated or specified, manufactured materials, products, processes, equipment, systems, assemblies, and the like shall be erected, installed, or applied in accordance with the manufacturer's instructions, directions, or specifications. Said erection, installation, or application shall be in accordance with printed instructions furnished by the manufacturer of the material or equipment concerned for use under conditions similar to those at the jobsite.

B. Any deviation from the manufacturer's printed installation instructions and recommendations shall be explained and acknowledged as correct and appropriate for the circumstances, in writing, by the particular manufacturer. The Contractor will be held responsible for installations contrary to the respective manufacturer's installations and recommendations.

1.07 SPECIALIST APPLICATOR/INSTALLER

A. Materials, equipment, systems, and assemblies requiring special knowledge and skill for the application or installation of such materials, equipment, systems, or assemblies shall be applied or installed by the specified product manufacturer or its authorized representative or by a skilled and experienced Subcontractor qualified and specializing in the application or installation of the specified product.

B. The installation Subcontractor shall be approved by the product manufacturer, as applicable.

1.08 MANUFACTURER'S FIELD SERVICES

A. The Contractor shall have the manufacturer of a product, system, or assembly that requires special knowledge and skill for the proper application or installation of such product, system, or assembly provide appropriate field or job service at no additional

cost to the District. The Contractor shall have the manufacturer inspect and approve the application or installation work.

B. The Contractor shall make all necessary arrangements with the manufacturer of the products to be installed to provide onsite consultation and inspection services to assure the correct application or installation of the product, system, or assembly.

C. The manufacturer's authorized representative shall be present at the time any phase of this work is started.

D. The Contractor shall have the manufacturer inspect and approve all surfaces over which, or upon which, the manufacturer's product will be applied or installed.

E. The Contractor shall have the manufacturer's representative make periodic visits to the site as the work progresses as necessary for consultation and for expediting the work in the most practical manner.

1.09 FINISHED TOLERANCE

A. Except as specified otherwise in the individual Specifications Sections, Sections, finished tolerances shall conform with the following requirements:

1. Walls: Finished wall surfaces shall be plumb and shall have a maximum variation of 1/8 inch in 8 feet when a straightedge is laid on the surface in any direction, and no measurable variation in any 2-foot direction.

2. Ceilings: Finished ceiling surfaces shall present true, level, and plane surfaces, with a maximum variation of 1/8 inch in eight feet when a straightedge and water level are laid on the surface in any direction, and no measurable variation in any two-foot direction.

3. Concrete Floors: Tolerances for concrete floors and pavement are specified in Section 03 35 00, Concrete Finishing.

4. Finished Floors: Finished floors shall be level to within plus or minus 1/8 in 10 feet. Where floor drains occur, slope finished floor to the drain at the rate of 1/8 inch per foot or as otherwise indicated on the Contract Drawings.

1.10 ENGINEER'S MONITORING

A. The Engineer will perform surveillance inspection of the Contractor's on-site construction activities. Surveillance inspection consists of a review, observation, or inspection of Contractor personnel, material, equipment, processes, and test results, performed at random or at selected stages of the construction operations. The purpose of surveillance inspection is to determine if an action has been accomplished or if documents have been prepared in accordance with selected requirements of the Contract Documents.

B. The Contractor shall provide access to the Work and shall furnish the Engineer reasonable facilities for obtaining such information as may be necessary to be fully informed of the quality and progress of the Work.

C. Surveillance inspection does not take the place of the Contractor's quality programs or assume any responsibility for such programs or the quality of the Work. The Contractor shall establish its own quality program, perform the required inspections, and provide the necessary documentation to assure that acceptable quality has been achieved. The Contractor is responsible for specifying and controlling the quality of work performed by its Subcontractors.

1.11 ENGINEER'S INSPECTIONS AND TESTS

A. The Engineer may perform inspections and tests as necessary to determine the Contractor’s compliance with Contract requirements. The Engineer may perform such additional inspections and tests as it deems necessary to verify compliance with Contract requirements.

B. For inspections and tests by the Engineer, the Engineer will provide the services of a qualified testing laboratory, soils engineer, or inspector, selected and paid for by the District.

C. The District-employed testing laboratory will supervise the preparation and selection of samples required for testing.

D. The Contractor shall provide such facilities and assistance as the testing laboratory may require for obtaining the necessary samples.

1.12 CONTRACTOR'S QUALITY CONTROL TESTING

A. Scope: The Contractor shall perform quality control inspections and tests as necessary to ensure compliance with Contract requirements.

B. Testing Services:

1. Quality control testing is the testing of materials prior to their delivery from a manufacturer, or during construction, such as soils compaction tests, load tests, concrete tests during placement, concrete strength tests, pipe leakage tests, and such other tests as are specified in the various Sections of the Specifications to ensure compliance with the Contract Documents. The Contractor shall assume full responsibility for quality control testing and shall give sufficient notice to the Engineer to permit the Engineer to witness the tests. Quality control testing shall be at the expense of the Contractor and shall be performed by a Contractor-employed independent testing firm.

C. Laboratory Tests: All laboratory testing shall be performed by an independent, qualified testing laboratory approved by the Engineer. The selected laboratory shall employ the proper equipment and qualified testing personnel for the testing specified in these Specifications. The Contractor shall obtain the Engineer's approval of the testing equipment and personnel. The Engineer may monitor the operations to

ensure that tests are being performing in accordance with approved procedures and in compliance with these Specifications.

D. Qualification of Laboratory Testing Personnel: Personnel performing laboratory tests shall be qualified for such work by virtue of prior experience and training.

E. Testing Equipment: Testing equipment shall be in satisfactory operating condition, of adequate capacity and range, and accurately calibrated. Testing equipment shall be calibrated in accordance with national standards which are certified by the National Institute of Standards and Technology. Testing equipment shall be calibrated at the frequency recommended by the equipment manufacturer.

1.13 TEST REPORTS

A. Test reports shall include the following information:

1. Actual test results compared with the Contract requirements and identification of all non-conforming items.

2. Calibration Certificates.

B. The Engineer will make available to the Contractor copies of all test reports of tests performed by the Engineer.

1.14 QUALITY CONTROL AUDITS

A. The Engineer may perform quality control audits of the Contractor's, Subcontractor's, and Supplier's quality records and performance. The Contractor shall ensure that all quality control records and places of work are open and available to the Engineer for inspection. The Engineer will give 30 Days' notice of intention to audit specific activities or installations.

B. The Contractor, Subcontractor, or Supplier being audited shall be available during the audit as required by the audit team.

1.15 CERTIFICATES OF COMPLIANCE

A. The Contractor may use certificates of compliance for certain materials and products in lieu of the specified sampling and testing procedures. Submit any certificates required for demonstrating proof of compliance of materials with specification requirements with each lot of material delivered to the Work. The lot so certified shall be clearly identified by the certificate. Certificates shall be signed by an authorized representative of the producer or manufacturer and shall state that the material complies in all respects with Contract requirements.

B. The Contract Schedule specified in Section 01 32 16, Construction Progress Schedule, shall indicate the date scheduled for the submittal of certificates. In the case of multiple shipments, each of which shall be accompanied by a certificate of compliance, the scheduled date on the Project CPM Schedule shall indicate the initial submittal only.

C. The certificate of compliance shall be accompanied by a certified copy of test results or shall state that such test results are on file with the producer or manufacturer and shall be furnished to the District on request. In addition to the identifying information specified for submittals in Article 1.05E of Section 01 33 00, Submittal Procedures, the name and address of the organization performing the tests, the date of the tests, and the quantity of material shipped.

D. Materials used on the basis of a certificate of compliance may be sampled and tested by the Engineer at any time. The fact that material is used on the basis of a certificate of compliance shall not relieve the Contractor of its responsibility for incorporating material in the Work which conforms to the requirements of the Contract, and any such material not conforming to such requirements will be subject to rejection, whether in place or not.

E. The District reserves the right to reject a certificate of compliance and require submittal and execution of sampling and testing procedures described herein.

1.16 SPECIAL INSPECTONS

A. Any special inspections required shall be executed by an independent inspection organization, not affiliated with the Contractor or its regular quality control organization.

PART 2 – PRODUCTS

Not Used

PART 3 – EXECUTION

Not Used

END OF SECTION 01 45 00

SECTION 01 45 24

TESTING PROGRAM REQUIREMENTS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Data to be recorded.

B. Tests.

C. Certified Test Reports.

1.02 RELATED SECTIONS

A. General requirements for training of BART personnel in the operation and maintenance of the various project electrical systems are specified in Section 01 79 00, Demonstration and Training.

B. Section 01 33 00, Submittal Procedures.

C. Section 01 33 23, Shop Drawings, Product Data and Samples.

D. Section 01 43 00, Quality Assurance.

E. Section 01 45 00, Quality Control.

1.03 MEASUREMENT AND PAYMENT

A. Separate measurement or payment will not be made for work required under this Section. All costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work.

1.04 COORDINATION

A. Submit written notice as to when the installed equipment and systems will be tested so that the Engineer can be present to witness the tests. Give a minimum of 15 calendar Days notice before performing the proposed tests.

B. Where specialized or heavy electrical equipment is involved, a representative of the manufacturer will be required to be present to witness the tests and verify the results.

1.05 SUBMITTALS

A. In addition to the Test Program Plan required in Section 01 43 00, Quality Assurance and the Quality Control Testing required in Section 01 45 00, Quality Control, specific equipment and/or systems require individual testing in accordance with the

Contract specification or the specific code requirements. These specific Contract and code required tests shall be performed as follows:

Testing Program: Submit overall test schedule and test procedures for review before beginning the testing of the equipment or systems. Each procedure shall, as a minimum include the following:

1. Statement of procedure objective and scope;

2. List of equipment required to set up and perform the procedure;

3. List of equipment or services required from areas outside the Contractor's authority;

4. List of prerequisite tests that need to be completed before the procedure can be performed;

5. Description of the required procedure setup, including diagrams illustrating test equipment connections and identifying test points, where applicable;

6. Step-by-step instructions for performing the procedure identifying the points where data is to be recorded and the limits for acceptable data;

7. Provisions for recording pertinent test conditions and environment at time of test; and

8. Instructions for recording data on data sheets and verifying that procedure steps have been completed.

B. Test Reports: Submit certified test reports of the results of tests performed on installed equipment or systems.

C. Instruments: Submit list of instruments and certification indicating that the instruments that will be used for testing have been calibrated and their accuracy certified within a previous period of not more than six months. List types of instruments to be used, manufacturer, serial number, latest date of calibration, and calibration organization.

1.06 GUARANTY

A. Tests shall not alter the Contractor's guaranty of the equipment. Replace and retest work and materials found to be in noncompliance with these Specifications at no additional cost to the District.

1.07 DATA TO BE RECORDED

A. Maintain reproducible test data sheets showing results of tests specified in the accepted test procedures. Provide reproducible data sheets, listing acceptable or specified test limits and values actually measured. Furnish one copy to the Engineer. Retain one copy.

B. Provide data sheets showing test set-up, equipment used, names of persons performing test, names of witnesses, date, location, and serial number of equipment under test, time of the test, test connection diagrams, clearly identified pass or fail criteria, expected and actual observed data and conditions, comment fields, test personnel including name, company, and contact information, and a section for signature approvals by the Contractor testing personnel and the Engineer witness from the District. Test data sheets shall be reviewed by the Engineer, and the Engineer may accept the test data sheets as submitted, or additional tests may be required. If additional tests are required because initial test results do not comply with these Specifications, the re-testing shall be documented and submitted as before at no additional cost to the District.

PART 2 – PRODUCTS

2.01 MATERIALS, EQUIPMENT, AND SERVICES

A. Provide test procedures, qualified technical personnel, tools, equipment, test instruments, facilities, and services as required to perform the testing. The Engineer will have qualified witnesses present at each test to observe the test results.

B. For the extended coverage test, (long duration and/or extensive area) provide qualified technical support personnel, tools, test instruments, and services on demand when given at least 24 hours notice.

C. The Contractor shall be present at all tests performed by others.

1. Verify that the interface parameters sought are in compliance with the test data sheets accepted by the Engineer; or

2. Perform work as necessary to ensure that the accepted interface parameters are met.

PART 3 – EXECUTION

3.01 TESTS

A. Verify that all required tests have been performed for the applicable specification for each installed equipment or system including all operating and testing requirements. This shall include all electrical, mechanical, plumbing, fire protection, communication and other equipment and /or system.

END OF SECTION 01 45 24

SECTION 01 51 00

TEMPORARY UTILITIES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Temporary electrical facilities.

B. Temporary water.

C. Temporary heat.

1.02 RELATED SECTIONS

A. Temporary toilet conveniences, washing facilities, and drinking water are specified in Section 01 52 00, Construction Facilities.

B. Section 01 33 00, Submittal Procedures

C. Section 01 57 00, Temporary Controls

D. Installation, placement, maintenance, and removal of temporary utilities shall be performed in accordance with Section 01 57 00, Temporary Controls.

1.03 MEASUREMENT AND PAYMENT

A. Separate measurement or payment will not be made for work required under this Section. All costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work.

1.04 REFERENCES

A. State of California, Department of Transportation (Caltrans), Standard Specifications:

Section 48 Temporary Structures.

B. Caltrans Standard Specifications, Article 48-2.03E, “Falsework Lighting.”

1.05 TEMPORARY ELECTRICAL FACILITIES

A. Electrical Services: Provide and maintain during the course and progress of the Work all electrical power and wiring requirements to facilitate the work of all trades and services associated with the Work. Electrical power shall be provided at the Contractor’s expense. The Contractor shall request the utility company to install temporary power poles in locations required. All temporary wiring, feeders, and connections shall be furnished by the Contractor, as required.

B. Falsework Lighting: Falsework lighting shall comply with the requirements of Caltrans Standard Specifications, Article 48-2.03E, “Falsework Lighting.” The Contractor shall submit a plan of the proposed falsework lighting installations in accordance with the submittal requirements of Section 01 33 00, Submittal Procedures.

1.06 TEMPORARY WATER

A. Provide temporary water service as required for the Work, at the Contractor’s expense. Closest availability of water shall be determined by the Contractor and shall be approved by authorities having jurisdiction before making the connection.

B. Provide temporary piping or hose to carry water to every point where needed. All water used shall be potable water, unless otherwise approved by the jurisdictional authority for a specific purpose.

1.07 TEMPORARY HEAT

A. Provide, at the Contractor’s expense, temporary heat as necessary for drying out the station facilities and other structures, curing of concrete, the proper installation of materials, and the protection of the Work, materials, and workers against injury from dampness and cold.

B. Fuel, equipment, and methods of heating shall be approved by the jurisdictional Fire Marshal before using.

PART 2 – PRODUCTS

Not Used

PART 3 – EXECUTION

3.01 CLEANUP

A. Remove all materials and equipment as a part of final cleanup.

END OF SECTION 01 51 00

SECTION 01 52 00

CONSTRUCTION FACILITIES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Temporary sanitary facilities.

B. Engineer's field office.

C. Contractor's field office.

D. Storage and parking areas.

E. Enclosed storage and shops.

F. Protective barricades and safety precautions.

G. Temporary fencing.

H. Security.

1.02 RELATED SECTIONS

A. Refer to the following sections for requirements

1. General Conditions Article GC9.8.1
2. Section 01 35 24, Construction Safety
3. Section 01 57 00, Temporary Controls
4. Section 32 31 13, Chain Link Fences and Gates

1.03 MEASUREMENT AND PAYMENT

A. Separate measurement or payment will not be made for work required under this Section. All costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work.

B. Provision for Engineer's Field Office shall be paid for as indicated on the applicable Bid Item in the Bid Schedule of the Bid Form.

1.04 GOVERNING LAWS

A. Temporary facilities shall be in compliance with applicable federal, state, county, municipal, and local utility laws, rules, and regulations. Nothing in these Contract Documents shall be construed to permit work not conforming with such codes and regulations.

1.05 TEMPORARY SANITARY FACILITIES

A. Provide adequate temporary toilet conveniences, washing facilities, and drinking water for the use of all employees and persons engaged on or about the Work, including Subcontractors and their employees. Drinking water shall be potable and drinking water facilities shall be clean and sanitary.

B. Locate sanitary facilities where approved by authorities having jurisdiction and maintain in a clean and sanitary condition during the course of the Work. Keep such facilities adequately supplied with toilet paper, paper toweling, paper cups, and related supplies as required.

C. At completion of the Work, sanitary facilities shall be properly disinfected and all evidence of same removed from the site.

1.06 ENGINEER'S FIELD OFFICE

A. Requirements:

1. For Contract base value greater than or equal to two and a half million dollars (≥$2,500,000) and less than ten million dollars (<$10,000,000), provide a single wide trailer. The Engineer's office shall have an enclosed floor space of at least 700 square feet within 100 square feet of counter space and 120 square feet of overhead shelving.

2. For Contract base value greater than or equal to ten million dollars (≥$10,000,000) and less than fifty million dollars (<$50,000,000), provide a double wide trailer with Conference Room. The Engineer's office shall have an enclosed floor space of at least 1400 square feet. The office shall be configured with two (2) small offices, one (1) large conference room, six (6) cubicles, and one (1) kitchenette/break area.

3. For Contract base value greater than or equal to fifty million dollars (≥$50,000,000), provide a double wide trailer with offices only. The Engineer's office shall have an enclosed floor space of at least 1400 square feet. The office shall be configured with four (4) small offices, six (6) cubicles, and one (1) kitchenette/break area.

4. Provide mobile units or temporary buildings, with water, sanitary facilities, electrical power, and parking facilities, hereinafter called the "Engineer's field office," for use by the Engineer and District representatives in administering the Contract. The Engineer's field office shall be situated in the work area at a location approved by the Engineer and adjacent to the Contractor's field office.

The Engineer's field office shall be furnished and ready for occupancy by the District within 30 Days after the effective date of the Notice to Proceed.

5. The Engineer's field office shall be maintained and serviced by the Contractor, as herein specified, until the final invoice has been submitted by the Contractor and approved by the District, as set forth in General Conditions Article GC9.8.1.

6. Mobile units shall have all the features specified herein. If the Contractor elects to provide a building or buildings in lieu of mobile units, the buildings shall conform to local building codes and shall have the features specified herein, with substitute materials allowable subject to approval of the Engineer.

B. Construction and Materials: Provide hauling, building, and connection permits. The field office shall be substantially constructed to provide office space for the construction time period specified in the Contract Specifications. Materials shall be good commercial quality. The amount of space (square feet) required for the Engineer's field office is specified in the Contract Specifications. As a minimum, provide the following features and facilities:

1. Exterior and interior surfaces, other than factory finished, painted with two coats of an approved paint of a color or colors approved by the Engineer. No painting will be required on aluminum or stainless steel surfaces.

2. Interior walls and ceilings paneled with finished plywood or gypsum wallboard of not less than one-half inch thickness, or other suitable material.

3. Floors covered with resilient flooring material such as vinyl composition tile or sheet vinyl flooring. Floors shall be constructed to withstand a live load of 50 psf.

4. One restroom minimum, each with lavatory, water closet, mirror, soap holder, toilet paper holder, and paper towel dispenser. Restroom shall comply with State and Federal accessibility requirements. Water supply may be from a self-contained water storage tank, and water closets may be self-contained, flushing chemical units. Lavatory, urinal, and water closet waste may drain into a self-contained holding tank.

5. Entrance doors shall comply with applicable State and Federal accessibility requirements.

6. Lighting of 100 foot-candles minimum at desk height uniformly in all areas except rest rooms. Provide restroom with adequate lighting.

7. Duplex electrical receptacles around interior walls at an approximate spacing of 10 feet on center.

8. An electric drinking fountain for furnishing cool water. Water supply for drinking fountain may be bottled drinking water.

9. An automatically controlled heating/cooling system.

10. Water, sewer, telephone, high-speed internet, and electrical utility connections as required. High-speed internet service with internet modem and high-speed wireless internet router, ten (10) wired ethernet connection with minimum download speed = 100 Mbps, Minimum upload speed = 50 Mbps shall be provided.

11. Adequate access from public streets shall be provided to the field office, together with parking spaces as specified in the Contract Specifications. Include spaces for handicapped parking stalls as specified in the Contract Specifications. The access roadway and parking area shall be graded for drainage and surfaced with temporary concrete or asphalt pavement in an approved manner.

C. Furnishings and Equipment: The single wide trailer shall be equipped with the following:

1. Three (3) L-shaped desks (approximately 72-inches by 60-inches) with six (6) lockable desk drawers (2 per table).

2. One (1) cubicle (approximately 72-inches by 72-inches by 56-inches high) with one (1) L-shaped desks (approximately 72-inches by 72-inches), with one (1) 3-drawer, 15-inches wide, keyed (1 per cubicle table), with one (1) overhead cabinet, 48-inches by 14-inches by 14-inches, keyed (1 per cubicle table).

3. One (1) folding table, 30-inches by 98-inches for break room.

4. Seven (7) swivel office chairs with wheels.

5. Two (2) 4-drawer metal file cabinets, 15-inches wide, keyed, UL 350 1-hour fire resistant.

6. Four (4) bookcases, 36-inches by 12-inches deep, 5 shelves.

7. Three (3) dry erase board, 48-inches wide by 36-inches high with markers and erasers.

8. Six (6) waste baskets, 7 gallon rectangular.

9. One (1) mobile plan rack, 12 bracket, 36-inches wide adjustable, vertical.

10. One (1) colored copier/scanner:

    a. Capability of copying/scanning 8-1/2 inches by 11 inches, 8-1/2 inches by 14 inches, and 11 inches by 17 inches double sided originals

    b. Automatic feed paper size selection with 2,500 sheet capacity bin sorter and stapler

    c. Service contract with maintenance including toner and ink replacements

    d. 30 pages per minute double sided 8-1/2 inches by 11 inches, 8-1/2 inches by 14 inches, and 11 inches by 17 inches double – colored and black and white

11. One (1) phone and fax machine, with answering capabilities on two lines.
12. One (1) refrigerator 18 cubic feet minimum volume.
13. One (1) microwave 1.7 cubic feet minimum volume.
14. One (1) water dispenser with hot and cold water.
15. One (1) small table, 48-inches by 36-inches minimum for kitchenette.
16. One (1) OSHA compliant 25 person First Aid Kit.
17. One (1) fire extinguisher – 2A:10B:C.
18. Two (2) smoke and CO detector – battery operated.
19. One (1) Shared Male/Female restroom.

D. Furnishings and Equipment for double wide trailer with conference room shall include the following:

1. One (1) L-shaped desks (approximately 72-inches by 60-inches) with six (6) lockable desk drawers (2 per table).
2. Two (2) drafting tables, 36-inches by 48-inches in plan room.
3. One (1) folding table, 30-inches by 96-inches in plan room.
4. One (1) conference room table, 12-feet by 4-feet minimum.
5. Six (6) cubicle (approximately 72-inches by 72-inches by 56-inches high). Each cubicle shall be equipped with one (1) L-shaped desk (approximately 72-inches by 72-inches), one (1) 3-drawer, 15-inches wide, keyed, one (1) overhead cabinet, 48-inches by 14-inches by 14-inches, keyed.
6. Twenty (20) swivel office chairs with wheels.
7. Four (4) 4-drawer metal file cabinets, 15-inches wide, keyed, UL 350 1-hour fire resistant.
8. Four (4) bookcases, 36-inches by 12-inches deep, 5-shelves.
9. Two (2) dry erase board, 48-inches wide by 36-inches high, with markers and erasers.
10. Twelve (12) waste baskets, 7 gallon rectangular.
11. Two (2) mobile plan rack, 12 bracket, 36-inches wide adjustable, vertical.

12. One (1) colored copier/scanner:

    a. Capability of copying/scanning 8-1/2 inches by 11 inches, 8-1/2 inches by 14 inches, and 11 inches by 17 inches double sided originals

    b. Automatic feed paper size selection with 2,500 sheet capacity bin sorter and stapler

    c. Service contract with maintenance including toner and ink replacements

    d. 30 pages per minute double sided 8-1/2 inches by 11 inches, 8-1/2 inches by 14 inches, and 11 inches by 17 inches double – colored and black and white

13. One (1) phone and fax machine with answering capabilities on 2 lines.

14. One (1) refrigerator 18 cubic feet minimum volume.

15. One (1) microwave 1.7 cubic feet minimum volume.

16. One (1) water dispenser with hot and cold water.

17. One (1) small table, 48-inches by 36-inches minimum for kitchenette.

18. One (1) OSHA compliant 25 person First Aid Kit.

19. One (1) fire extinguisher – 2A:10B:C.

20. Two (2) smoke and CO detector – battery operated.

21. One (1) shared Male/Female restroom.

E. Furnishings and Equipment for double wide trailer with offices only shall include the following:

1. Three (3) L-shaped desks (approximately 72-inches by 60-inches) with six (6) lockable desk drawers (2 per table).

2. Two (2) drafting tables, 36-inches by 48-inches in plan room.

3. One (1) folding table, 30-inches by 96-inches in plan room.

4. Six (6) cubicle (approximately 72-inches by 72-inches by 56-inches high). Each cubicle shall be equipped with one (1) L-shaped desk (approximately 72-inches by 72-inches), one (1) 3-drawer, 15-inches wide, keyed, one (1) overhead cabinet, 48-inches by 14-inches by 14-inches, keyed.

5. Fourteen (14) swivel office chairs with wheels.

6. Six (6) 4-drawer metal file cabinets, 15-inches wide, keyed, UL 350 1-hour fire resistant.

7. Eight (8) bookcases, 36-inches by 12-inches deep, 5-shelves.

8. Four (4) dry erase board, 48 inches wide by 36-inches high, with markers and erasers.

9. Twelve (12) waste baskets, 7 gallon rectangular.

10. Two (2) mobile plan rack, 12 bracket, 36-inches wide adjustable, vertical.

11. One (1) colored copier/scanner:

    a. Capability of copying/scanning 8-1/2 inches by 11 inches, 8-1/2 inches by 14 inches, and 11 inches by 17 inches double sided originals

    b. Automatic feed paper size selection with 2,500 sheet capacity bin sorter and stapler

    c. Service contract with maintenance including toner and ink replacements

    d. 30 pages per minute double sided 8-1/2 inches by 11 inches, 8-1/2 inches by 14 inches, and 11 inches by 17 inches double – colored and black and white

12. One (1) phone and fax machine, with answering capabilities on 2 lines.

13. One (1) refrigerator 18 cubic feet minimum volume.

14. One (1) microwave 1.7 cubic feet minimum volume.

15. One (1) water dispenser with hot and cold water.

16. One (1) small table, 48-inches by 36-inches minimum for kitchenette.

17. One (1) OSHA compliant 25 person First Aid Kit.

18. One (1) fire extinguisher – 2A:10B:C.

19. Two (2) smoke and CO detector – battery operated.

20. One (1) shared Male/Female restroom.

F. Services: Provide maintenance, utility, and janitorial services throughout the specified period as follows:

1. Repair and daily cleaning of the field office, parking, and access area.

2. The furnishing of drinking water, paper cups and towels, toilet paper, light bulbs, and such other basic necessities required for the operation and maintenance of the field office. For mobile units with holding tanks, provide periodic removal of waste material and cleaning of holding tank as required. Provide self-contained water storage tank with fresh, potable water as required. Refill when tank is down to 1/4 full.

3. Provide security measures and area protection equivalent to that used by the Contractor for the Contractor’s jobsite shop and field office facilities.

4. Provide services for utilities indicated in Article 1.05.B.10, including monthly charges, account fees, service charges, connection fees and deposits. Telephone service shall include long distance costs.

1.07 CONTRACTOR'S FIELD OFFICE

A. The Contractor shall provide and maintain, in good condition, on the site or near the site as approved by the Engineer, a temporary field office of suitable size for construction administrative operations and consultations with representatives of the District.

B. The Contractor's field office shall contain a complete set of Contract Documents.

C. The Contractor shall make arrangements and pay all costs, including service and toll charges, until Substantial Completion of the Work, for temporary telephone service in the temporary field office, for use by the Contractor and Subcontractors, for purposes related to the Work.

D. If no Engineer's field office is required, the Contractor's field office shall include the following for the exclusive use of the Engineer:

1. A minimum 30 inches by 60 inches metal table with four chairs.

2. A lockable metal two drawer filing cabinet. Furnish the Engineer with two sets of keys. The Contractor shall not retain any key to this cabinet.

1.08 STORAGE AND PARKING AREAS

A. The Contract Drawings may indicate work areas available to the Contractor for storage of materials and for parking of construction equipment. If so indicated, these areas will be provided to the Contractor for the durations indicated in the Contract Specifications. Additional work and storage space, if required, shall be provided by the Contractor at Contractor's expense.

B. The Contractor shall provide parking facilities for the Contractor's personnel, Subcontractors, supplier's delivery vehicles, and authorized visitors. Off-site parking facilities (if any) shall not impair or interfere with existing community parking and traffic conditions, regulations, and restrictions.

1.09 ENCLOSED STORAGE AND SHOPS

A. The Contractor shall provide all temporary storage and shop rooms that may be required at the jobsite for safe and proper storage of tools, materials, and equipment. Construct such rooms only in locations indicated or as approved by the Engineer, and so as not to interfere with the proper installation and completion of other work.

B. Remove such rooms within three Days of receipt of notices from the Engineer that removal is necessary, and incur all expenses for such removal.

C. Storage of gasoline or similar fuels shall conform to NFPA regulations and local fire department regulations and shall be confined within definite boundaries apart from buildings as approved by the Engineer and the jurisdictional fire marshal.

1.10 PROTECTIVE BARRICADES AND SAFETY PRECAUTIONS

A. Construct and maintain barricades, lights, shoring, and warning signs as required by Federal and State safety ordinances and as required to protect the District's property from injury or loss and as necessary for the protection of the public and adjacent properties. Provide walks around obstructions made in a public place for executing the Work. Leave all protection in place and maintain until removal is authorized.

B. Maintain access to and clearly mark Fire Department Connection (FDC).

C. Guard and protect all workers, pedestrians, and the public from excavations, construction equipment, obstructions, and other dangers with adequate railings, guard rails, temporary walks, barricades, warning signs, directional signs, overhead protection, planking, decking, danger lights, and other suitable safeguards.

D. Flaggers shall be provided to direct or divert pedestrian or vehicular traffic when necessary as specified in Section 01 57 00, Temporary Controls.

E. Additional safety requirements are specified in Section 01 35 24, Construction Safety.

1.11 TEMPORARY FENCING

A. The Contractor shall furnish, construct, maintain, and later remove temporary fencing around the jobsite perimeter as indicated. Contractor is responsible for all maintenance of temporary fence, including but not limited to removal of graffiti within 24 hours and preventing fence from falling over.

B. Except as otherwise specified herein, temporary fencing shall conform to Specifications Section 32 31 13, Chain Link Fences and Gates.

C. Used materials may be employed for temporary fencing, provided such used materials are good, sound, and are suitable for the purpose intended.

D. Fencing materials may be commercial quality, provided the dimensions and sizes of said materials are equal to, or greater than, the dimensions and sizes indicated in Specifications Section 32 31 13, Chain Link Fences and Gates. Additional fencing options include the following:

1. Posts may be either metal or wood.

2. Galvanizing and painting of steel items will not be required.

3. Treating wood with wood preservatives will not be required.

4. Concrete footings for metal posts will not be required, except where portable footings are required for temporary anchorage of posts.

E. Temporary fencing that is damaged from any cause during the progress of the Work shall be repaired or replaced by the Contractor at no additional cost to the District.

F. When no longer required for the Work, temporary fencing shall be removed. Removed fencing and related materials shall become the property of the Contractor and shall be removed from the jobsite, except as otherwise provided herein.

G. Holes caused by the removal of temporary fences shall be properly filled to match adjacent surfaces.

H. In public areas, temporary fencing stands, supports, and corners shall be made obvious with high visibility safety cones secured at each fence stand and support. Temporary fencing in public parking areas shall have reflective cones at each corner. Fencing may also require additional reflectors when requested by the Engineer. Ensure that fence supports shall support screened fencing during wind events. Temporary fencing and gates shall be inspected regularly during daily inspections. Screen fencing and supports shall be designed to withstand wind loading in accordance with Caltrans False Work Manual. Submit engineering calculations stamped by engineer responsible in change holding the current California Civil or Structural Engineer registration.

1.12 SECURITY

A. The Contractor shall provide for security of the Work and the Jobsite until final inspection and Acceptance of the Work. Storage areas shall be suitably fenced and lighted and routinely patrolled by security guards.

B. The District assumes no responsibility for protection of structures and finished work or for loss of materials and equipment from the time that Contract operations have commenced until Acceptance of the Work.

C. If watchman service is deemed necessary by the Contractor, such protection shall be provided by the Contractor, and all costs therefore shall be paid for by the Contractor.

D. Damaged, lost, or stolen materials and equipment, whether or not stored or already installed, shall be replaced by the Contractor with new specified materials and equipment, including reinstallation where applicable, at no additional cost to the District.

PART 2 – PRODUCTS

Not Used

PART 3 – EXECUTION

3.01 CLOSEOUT

A. Upon completion of the Work, or prior thereto when required by the Engineer, remove temporary facilities' structures and installations from the District's property.

B. Return exterior areas utilized for temporary facilities to their original, natural state or, when called for on the Contract Documents, complete such areas as indicated.

END OF SECTION 01 52 00

SECTION 01 57 00

TEMPORARY CONTROLS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Traffic plan and controls.

B. Pedestrian and patron controls.

C. Construction operations under traffic.

D. Portable changeable message sign.

E. Pollution abatement.

F. Erosion and sediment control.

G. Dust control.

H. Mud control.

I. Noise control.

J. Protection and use of escalators and elevators.

1.02 MEASUREMENT AND PAYMENT

A. Measurement:

1. Traffic maintenance and control will be measured for payment as a lump-sum unit, and will include only the items specified herein under Articles 1.04, 1.05, and 1.06.

2. All other items of temporary controls will not be measured for payment, but will be considered incidental to the Work of this Contract.

B. Payment:

1. Traffic maintenance and control will be paid for at the Contract lump-sum price as designated in the Bid Schedule of the Bid Form.

2. All other items of temporary controls will not be paid for separately but will be considered incidental to the Work.

1.03 REFERENCES

A. State of California, Department of Transportation (Caltrans), Standard Specifications:

1. Section 12 Temporary Traffic Control

2. Section 82 Signs and Markers

B. State of California, Department of Transportation (Caltrans), California Manual of Uniform Traffic Control Devices (California MUTCD), Part 6, Temporary Traffic Control.

C. State of California, Vehicle Code.

D. American National Standards Institute (ANSI)/Acoustical Society of America (ASA) S1.4: America National Standard Specification for Sound Level Meters.

E. USDOT 2009 Manual on Uniform Traffic Control Devices (MUTCD).

F. California Building Code.

G. Americans with Disability Act (ADA).

H. Architectural Barriers Act Accessibility Guidelines.

I. State Water Resources Control Board (SWRCB).

1.04 SUBMITTALS

A. Pedestrian handling plan.

B. Traffic plan and permits.

C. Water Pollution Control Plan (WPCP).

D. Storm Water Prevention Plan (SWPPP).

E. QSD and QSP qualifications.

1.05 PEDESTRIAN AND PATRON CONTROLS

A. Pedestrian Handling Plan

1. The Contractor shall prepare a pedestrian handling plan for the Work to reflect any changes in pedestrian and patron paths including the accessible path. The accessible path shall be as determined by the District in accordance with the requirements of California Building Code and the Americans with Disabilities Act and Architectural Barriers Act Accessibility Guidelines. The pedestrian handling plan shall include drawing(s) showing proposed pedestrian handling devices including temporary signage and wayfinding signs. The Contractor shall submit the plan for review and approval by the Engineer. Where the plan affects public right-of-way controlled by other jurisdictions, the Contractor shall also apply to

the jurisdictional agency for approval and obtain the necessary permits. All pedestrian handling devices and signage shall be in compliance with the accessibility requirements of the California Building Code and the Americans with Disabilities Act and Architectural Barriers Act Accessibility Guidelines.

2. Include pedestrian handling plans for each phase of the work requiring different pedestrian diversion patterns and methods of control. Include for each phase detailed schedules for performance of work and include proposed pedestrian handling devices.

3. Where overhead protection is required for walkways during construction, the requirement for Covered Walkways of Chapter 33 of California Building Code shall be followed.

B. Work Area Controls

1. All construction work within and around the facilities of the BART Operating System shall be separated from the public with appropriate barriers to prevent public access to construction areas and to contain construction hazards.

2. When the construction work is not within the jobsite perimeter fence as specified in Section 01 52 00, Construction Facilities, a barrier shall be placed around the construction work area to prevent public access to the work area and to protect the public from construction operations. The area to be enclosed within barriers shall not encroach into an exit path nor block the access path to elevators, escalators or stairways. Barriers on the platform level shall not be closer than seven feet from the platform edge. Barriers on the concourse level shall not interfere with access to fare gates or automatic fare collection vending equipment unless approved by the Engineer in writing.

3. A barrier that will be removed at the end of the work hours or work shift is a short-term barrier. Work performed within a short-term barrier must be able to be safely secured and not present a hazard to the public when the barrier is removed. Short-term barriers can be portable crowd control barriers, traffic delineator connected with rails to form a solid barrier, or other field constructed barriers approved by the Engineer.

4. A barrier that protects work that cannot be safely secured, is a hazard to the public, or remains in place after the end of the work hours or work shift is a long-term barrier. Long-term barriers shall be a minimum of eight feet in height. Long-term barriers shall be designed and constructed in accordance with the requirements of the California Building Code and shall be constructed with fire resistant materials. Calculations and drawings shall be stamped and signed by a licensed California civil or structural engineer and submitted to the Engineer. The use of fire retardant treated lumber and plywood is acceptable. Long-term barriers shall be painted and maintained free of graffiti. Paint color shall be per the Engineer.

5. Any long-term barriers that require ingress-egress or emergency access, security or locking, shall have BART Police Department and applicable ingress-egress locks daisy chained for 24-hour access as applicable.

1.06 TRAFFIC PLAN AND CONTROLS

A. Traffic Plan and Permits:

1. The Contractor shall prepare a traffic plan required for the Work. The traffic plan shall include drawings showing proposed traffic control devices including temporary signage and temporary pavement markings and striping. The Contractor shall apply to the jurisdictional agency for approval of the plan and for a permit or permits to work in the public right-of-way.

2. Include traffic plans for each phase of the work requiring different traffic diversion patterns and methods of control. Include for each phase detailed schedules for performance of work and include proposed traffic control devices.

B. Control Devices and Facilities:

1. Furnish, install, operate, maintain, and remove when no longer required, all traffic control and protective devices required for the approved traffic plan.

2. Traffic control and protective devices shall include temporary directional electrical warning signs, detour signs, and danger signals; temporary barricades and guard rails; crash cushions; temporary lighting, overhead warning lights and flashing lights; temporary pavement markings, and removal of permanent and temporary pavement markings; and the services of qualified flaggers.

3. Maintain communication with the jurisdictional agency(s) regarding the Contractor's operations in maintaining and controlling traffic.

C. Traffic Control Signs: Each change in location of traffic shall be adequately posted with signs mounted on barricades or standard posts in accordance with requirements of Caltrans Standard Specifications, Section 12. Temporary "No Parking" signs that are to be used for short periods will be provided by local authorities. The Contractor shall make arrangements for providing temporary no parking signs.

D. Pavement Marking: Install necessary temporary and permanent pavement marking as required in connection with the temporary street work and remove or obliterate existing or temporary pavement markings whenever vehicle traffic is moved to a newly available pavement area or to different traffic patterns. Refer to Section 32 17 23, Pavement Markings, for requirements.

E. Prior to starting work on each phase requiring traffic control, demonstrate to the satisfaction of the Engineer that necessary materials, equipment, and personnel are on site and that, once started, work can be completed in an expeditious manner without interruptions.

F. Redirecting Traffic:

1. All channelizing, shifting of traffic lanes, and barricading of traffic in connection with the Work will be subject to approval of the appropriate jurisdictional agency. Existing local standards for signing and marking of construction areas will apply in addition to the requirements of Caltrans Standard Specifications, Section 12.

2. When required by the Contract Specifications, or indicated on the Contract Drawings, or required by responsible public agencies, the Contractor shall construct, maintain, and remove detours and detour bridges for the use of public traffic.

3. Failure or refusal of the Contractor to construct and maintain detours at the proper time shall be sufficient cause for closing down the Work until such detours are in satisfactory condition for use by public traffic.

G. Temporary Closing to Traffic: Prior to temporary closing to traffic of any street, sidewalk, or other access, or to changing traffic patterns from those indicated on the Contract Drawings, obtain approval from appropriate jurisdictional authority, and comply with imposed conditions, at least two weeks before such closures or changes are made. Deviations will be for an emergency condition affecting life and property only, and the Contractor shall immediately notify the Engineer and the appropriate jurisdictional authority of any such emergency changes. Copies of all approvals shall be furnished to the Engineer.

H. Temporary Walkways: In areas where removal of existing sidewalks is necessary, access to adjacent businesses, entrances, and properties shall be maintained by temporary walkways having a width of not less than four feet.

I. Intersections and Street Crossings: Intersections and street crossings shall be excavated and decked in stages as indicated. Construction shall be phased so that the required number of traffic lanes on each street will be provided at all times during these operations. Upon completion of decking installation, traffic in all directions shall be fully maintained. Trenches or open excavations shall be properly bridged where traffic lanes are to be open to traffic.

J. Temporary Paving and Patching: Construct, maintain, and remove temporary pavement and patching required to safely and expeditiously handle vehicle and pedestrian traffic, within or adjacent to the jobsite. Temporary pavement and patching composition shall conform to the specifications of the local jurisdictional authority. Any construction, maintenance, or removal required by the Contractor’s operations off site shall conform to the requirements specified herein.

K. New and Existing Traffic Control Devices:

1. The Contractor shall arrange with the respective county and municipal authorities to provide governmental services as required for salvaging reusable street-name and traffic signs, removal of parking meters, and for removal, relocation, and adjustment of traffic signals.

2. The Contractor shall provide such work and construction services as may be required by county and municipal authorities to assist in salvaging reusable street-name and traffic signs, removing of parking meter posts and bases, and removing, relocating, and adjusting of traffic signals, all in accordance with jurisdictional standards and regulations.

1.07 CONSTRUCTION OPERATIONS UNDER TRAFFIC

A. Definitions: “Construction equipment” is defined for the purposes of this Article as all types of equipment, vehicles, and tools used in connection with construction work. The term “workers” includes every person or firm performing work in or adjacent to public streets.

B. Construction Equipment: When in traffic lanes, all vehicles and equipment shall be operated at normal traffic speeds. If this is not practicable, a slow moving vehicle emblem shall be displayed in accordance with the California Vehicle Code. Construction equipment shall not be parked in any lane intended for use by normal traffic. Equipment parked or stored at the work site shall be behind a guard rail, barrier, curb, or other protective device.

C. One-Way Traffic: No construction equipment shall be operated in traffic lanes, except in the designated direction of travel for respective lanes.

D. Construction Operations:

1. Schedule surface operations so that work is not carried on intermittently throughout the area. Excavation or construction activities shall be scheduled and pursued to completion as required to permit opening of street areas to traffic without unnecessary delays.

2. No construction work involving occupancy of traffic lanes shall be performed during adverse weather conditions or adverse road conditions, and traffic shall be properly safeguarded by the use of flashers and lights in addition to the signs and other markings specified herein. During these periods, no construction deliveries shall take place over a travel lane or immediately adjacent thereto.

3. When traffic conditions dictate, the Contractor shall modify its work operation for such length of time as required to alleviate the hazardous traffic conditions.

E. Equipment Travel:

1. No construction equipment other than that designated and used for general highway transportation shall be moved on streets during hours of darkness or periods of adverse weather conditions that reduce normal visibility.

2. Any construction equipment or material required for construction operations which exceeds the maximum vehicle dimensions specified in the Motor Vehicle Code, shall be moved only in accordance with established State and local regulations. No such oversize load shall be moved over public streets without first obtaining approval of the appropriate jurisdictional authority.

F. Crossing Traffic Lanes: Construction equipment entering the traveled way from the median shall be safeguarded by a portable changeable message sign and with flaggers as required. Where traffic speeds are high, slow-moving construction equipment entering the traveled way shall be protected by a “rolling barricade” supplied by the California Highway Patrol (CHP). This operation shall be performed at off-peak hours, and requires coordination between the Contractor and the CHP, with the cost being borne by the Contractor.

G. Flaggers: When flagging is required, provide qualified flaggers and flagging in accordance with the requirements of the California MUTCD, Part 6.

H. Removal of Traffic Control Devices: All temporary signs, barricades, barrier curbs, crash cushions, drums, and cones used to safeguard traffic in connection with construction work shall be removed at the close of the work day, unless the state of the work is such that warning devices are still needed and are adapted for night closing.

I. Storage: No material or traffic control devices shall be stored on any lane intended for traffic use.

1.08 PORTABLE CHANGEABLE MESSAGE SIGN (CMS)

A. When conditions warrant, portable changeable message signs shall be furnished, placed, operated, and maintained at locations indicated or designated by the Engineer, in accordance with Section 12-3.01. “General,” of the Caltrans Standard Specifications.

B. A CMS shall be placed at a location 800 to 1000 feet upstream from the beginning of temporary barriers alerting motorists of slow trucks entering or leaving the median.

C. The message shall read: “CAUTION – SLOW TRUCKS AHEAD,” unless other words are required by the Engineer.

D. The CMS shall be in continuous operation during the hours when trucks are entering or leaving the median at a rate greater than two trucks per hour.

E. When two trucks or less per hour are leaving the median, the CMS shall be in operation only during the time when trucks are entering the traveled way. The CMS shall be turned off after the truck has safely entered the traveled way.

F. Each portable changeable message sign unit shall consist of a three-line matrix sign panel, a controller unit, a power supply, and a structural support system all mounted on a trailer. The unit shall be assembled to form a complete self-contained portable changeable message sign that can be delivered to the site of the work and placed in immediate operation. The complete message sign unit shall be capable of operating in an ambient air temperature range of minus 20 degrees Celsius to plus 70 degrees Celsius and shall not be affected by mobile radio transmissions.

G. The trailer shall be equipped with at least three adjustable outrigger leveling pads near the frame corners to permit stable job site installations. The unit shall be capable of resisting overturning under wind loads of 60 mph with the sign in the fully elevated position. The overall width of the trailer unit, including the sign and mounting brackets, shall not exceed 102 inches while being towed.

H. The message displayed on the sign shall be visible from 1200 feet and shall be legible from a distance of 750 feet, at noon on a cloudless day, by persons with vision corrected to 20/20. The sign shall be capable of displaying a minimum of eight characters per line on each of three lines.

I. The sign face shall be flat black and shall be protected from sun-glare by a method that does not interfere with the clarity of the sign message. The sign shall be raised and lowered by means of a power-driven lifting mechanism.

J. The matrix sign shall be capable of a complete alphanumeric selection.

K. Lamp matrix type signs shall be equipped with an automatic dimming operational mode which automatically compensates for the influence of a temporary light source or other abnormal lighting conditions. The sign shall have manual dimming operation modes of three or more different lamp intensities.

L. Non-lamp matrix signs shall be internally illuminated at night.

M. The controller shall be an all solid-state unit containing all the necessary circuitry for the storage of at least five pre-programmed messages. The controller shall be installed in a location allowing the operator to perform all functions from one position. A keyboard entry system shall be provided to allow an operator to generate an infinite number of additional messages over the preprogrammed five. The keyboard shall be equipped with a security lockout feature to prevent unauthorized use of the controller.

N. The controller shall contain a non-volatile memory to hold the keyboard created messages in memory during a non-power period. It shall allow for a variable message display rate that allows the operator to match the information display to the speed of the approaching motorists. The flashing off time shall be operator adjustable within the control cabinet.

O. Full operation height shall be with the bottom of the sign at least seven feet above the ground and the top no more than 14 feet, six inches above the ground.

P. The portable changeable message signs, when no longer required for the work, shall become the property of the Contractor.

1.09 POLLUTION ABATEMENT - GENERAL REQUIREMENTS

A. Refer to General Conditions Article GC7.10. Conduct construction operations in a manner that will minimize pollution of the environment surrounding the area of the Work by all practicable means and methods. Apply specific controls as specified in the Contract Specifications and as follows:

1. Waste Materials: No waste or eroded materials shall be allowed to enter natural or man-made water or sewage removal systems. Eroded materials from excavations, borrow areas, or stockpiled fill shall be contained within the Work area. The Contractor shall develop methods for control of erosion as specified in Article 1.08, herein.

2. Burning: No burning of waste materials or debris will be permitted.

3. Burying: No burying of waste materials and debris will be permitted within the limits of the District's property.

B. Provide for and maintain the flow of all sewers, drains, building or inlet connections, and all water courses which may be encountered during progress of the Work. Do not allow the contents of any sewer, drain, or building or inlet connection to flow into trenches. Immediately remove from proximity of the Work all offensive matter, using such precautions as are required by local authorities having jurisdiction.

1.10 EROSION AND SEDIMENT CONTROL

A. Requirements:

1. The Contractor shall prevent erosion of excavated areas, embankments, stockpiled earth materials, and other erodible areas, and shall provide control of runoff sediment from siltation and pollution of the drainage systems.

2. Prevent erosion of excavated areas, embankments, stockpiled earth materials, and other erodible construction areas, and prevent pollution of drainage systems by diversion of storm runoff around construction activities or by trapping or retaining sediment delivered by storm runoff.

3. Provide control of construction operations and implementation of storm water best management practices to prevent sediment or siltation and from being introduced into municipal separate storm sewer systems (MS4) or other storm drainage systems from Construction site storm runoff.

4. Comply with all applicable Federal, State, and local laws, orders, and regulations concerning the prevention, control, and abatement of water pollution. The Contractor shall be responsible for fines, penalties, and damages assessed or levied on the Contractor or the District by any regulatory agency as a result of the Contractor's failure to comply with the provisions of this Section. The District may retain any money due the Contractor under the Contract for any fines, penalties, or damages as a result of the Contractor's failure to comply with the requirements of this Section.

5. For Contracts that require disturbance of one acre or more of land as defined by the State Water Resources Control Board (SWRCB), the following additional requirements shall apply:

    a. The Contractor shall comply with the requirements of the SWRCB National Pollutant Discharge Elimination System (NPDES) General Permit for Stormwater Discharge Associated with Construction and Land Disturbance Activities, SWRCB Order No. 2009-009-DWQ (the "SWRCB Order").

    b. The District will submit a Notice of Intent (NOI) and other elements of the Permit Registration Documents (PRD) required by SWRCB. The Contractor shall assist the District by submitting a completed hard copy of the NOI form, the site specific site map(s) and the Storm Water Pollution Prevention Plan (SWPPP) for review, approval and inclusion in the PRD. The site plan and SWPPP shall be submitted to the District electronically (PDF format preferred).

    c. The Contractor may not perform any land disturbing activities until the PRD has been approved by the SWRCB and a Waste Discharge ID number is issued by SWRCB. A copy of the complete PRD package, together with all approved amendments, shall be kept at the Jobsite at all times.

6. For Contracts that require disturbance of less than one acre of land as defined by the District's State Water Resources Control Board, pursuant to Water Quality Order No. 2013-0001-DWQ National Pollutant Discharge Elimination System (NPDES) General Permit No. CAS000004, the Contractor shall comply with the requirements of the District's General Permit for Phase II Small MS4 General Permit 2013-0001-DWQ.

    a. The Contractor shall prevent the discharge of pollutants to storm drainage systems via the installation, implementation, and maintenance of best management practices (BMPs), consistent with the California Storm Water Quality Association (CASQA) Best Management Practice Handbooks or equivalent.

B. Erosion and Sediment Control Plan:

1. Within 30 Days after the effective date of the Notice to Proceed, the Contractor shall submit a Water Pollution Control Plan (WPCP) or Storm Water Pollution Prevention Plan (SWPPP) for erosion and sediment control for the Engineer's approval.

2. The proposed plan or program shall indicate complete design and construction details and locations of all proposed temporary control structures, barriers, berms, sediment retention basins, and any other salient features.

3. Approval of the Contractor's proposed plan or program shall not relieve the Contractor of responsibility for designing, constructing, operating, and maintaining erosion and sediment control facilities in a safe and systematic manner, and for repairing any damage to the control structures and equipment caused by floods or excessive storm runoff or other unforeseen circumstance.

4. For Contracts that require disturbance of one acre or more of land as defined by SWRCB, the following additional requirements shall apply:

    a. The SWPPP shall include, but not be limited to, the following:

        1) Site map(s) which show(s) the construction site perimeter, existing and proposed storm drain inlets, buildings, lots, roadways, stormwater collection and discharge points, general topography both before and after construction, and drainage patterns across the construction site to local stormwater collection points.

        2) Identification of potential sources of pollution.

        3) A plan to eliminate non-storm water discharges, such as wash water, spills and excess dust control water.

        4) BMPs that have demonstrated effectiveness at reducing stormwater pollution.

        5) Procedures for notification of the Engineer in case of spills.

        6) Erosion and sediment control measures as specified herein.

        7) Mud control measures as specified herein.

        8) Procedures for containment and disposal of construction-generated spoils and waste water.

    b. The SWPPP shall be prepared by a Qualified SWPPP Developer (QSD) as defined in the SWRCB Order, and shall be implemented by a Qualified SWPPP Practitioner (QSP) as defined in the SWRCB Order. Within five Days after the Notice to Proceed, the Contractor shall submit information to demonstrate that the QSD and QSP conform to the requirements of the SWRCB Order.

    c. The General Permit Risk Level shall be as indicated in the Contract Documents. The Contractor shall notify the Engineer immediately if, in its opinion, a different level should be considered.

    d. The Contractor shall submit the SWPPP for review and approval not later than 30 Days after Notice to Proceed.

5. For Contracts that require disturbance of less than one acre of land as defined by the SWRCB, the following additional requirements shall apply:

    a. The WPCP shall include, but not limited to, the following:

        1) Site map(s) which show(s) the construction site perimeter, existing and proposed storm drain inlets, buildings, lots, roadways, storm water collection and discharge points, general topography both before and after construction, and drainage patterns across the construction site to local storm water collection points.

        2) Identification of potential sources of pollution.

        3) A plan to eliminate non-storm water discharges, such as wash water, spills and excess dust control water.

4) BMPs that have demonstrated effectiveness at reducing storm water pollution.

5) Procedures for notification of the Engineer in case of spills including emergency call numbers for Spill Control Plan.

6) Erosion and sediment control measures as specified herein.

7) Mud control measures as specified herein.

b. Procedures for containment and disposal of construction-generated spoils, solid waste and waste water shall be as follows:

1) The WPCP shall be prepared by a Qualified SWPPP Developer (QSD) or Qualified SWPPP Practitioner (QSP), as defined in the SWRCB Order, and shall be implemented by the same. Within 10 Days after the Notice to Proceed, the Contractor shall submit information to demonstrate that the QSD or QSP conform to the requirements of the SWRCB Order, and are currently registered with the California Storm Water Quality Association (CASQA).

2) Go to: https://dot.ca.gov/programs/construction/storm-water-and-water-pollution-control and prepare WPCP using Caltrans' latest WPCP template or equal.

3) The Contractor shall submit the WPCP for review and approval no later than 30 Days after Notice to Proceed.

C. Prevention of Erosion:

1. Protect open excavations, trenches, embankments, and the like with barriers, berms, dams, waterproof coverings, or other measures as required to prevent erosion of open earth areas and excavated piles from storm runoff.

2. Protect stockpiled earth materials to prevent erosion. Contract shall be responsible for installing and maintaining BMPs associated with stockpiling, trenching, and other earthwork operations.

3. Where natural drainageways are intercepted by construction activities, such drainageways shall be protected so that runoff from the site or water from construction activities is not allowed to enter the natural drainage way.

D. Sediment Control:

1. Sediment retention basins shall be constructed only when there are no other, more economical, measures that can be employed to prevent sediment from entering streams, drainage systems, and storm sewers during storm runoff.

2. Sediment control shall be achieved by well-planned and scheduled excavation and backfill operations and effective control measures.

E. Removal of Temporary Structures: Erosion and sediment control structures and facilities shall be removed from the site upon completion of the affected work.

F. SWPPP Implementation:

1. The Contractor shall implement the SWPPP as approved by the District. The Contractor shall conduct and document inspections of all sites included in the SWPPP as a minimum weekly throughout the year, as specified in the SWRCB Order. The Contractor shall also conduct and document inspections prior to anticipated storm events and during and after actual storm events to identify areas contributing to storm water discharge, and to evaluate whether measures to reduce pollutant loading identified in the SWPPP are adequate and properly implemented. The Contractor shall modify as necessary any measures found to be inadequate in controlling storm water discharges.

2. If the Engineer identifies a deficiency in the implementation of the approved SWPPP, the deficiency shall be corrected immediately, unless an agreed date for correction is approved in writing by the Engineer. The Contractor's failure to correct identified deficiencies by agreed upon dates shall be cause for the Engineer to suspend work until such corrections are made.

3. For each progress period during which the Contractor fails to conform to the approved SWPPP, the Engineer may withhold up to 25 percent of the progress payment or the value of the SWPPP work that the Contractor has failed to perform, whichever is higher.

4. The Contractor shall submit an annual report as specified in Section XVI of the SWRCB Order between July 1st and July 15th of each year to the Engineer for review and approval. The final approved annual report shall be submitted in a format suitable for the District's signature.

5. Upon completion of all activities under the Contract that may cause ground disturbance or stormwater runoff, the Contractor shall complete a Notice of Termination in accordance with the SWRCB Order and submit it to the Engineer for review and approval. After the Engineer's review and approval, the Notice of Termination shall be submitted in a format suitable for submittal to the SWRCB, which will further review and approve the Notice of Termination. It is anticipated that SWRCB will require approximately 30 Days for this review. The Contractor shall be responsible for revising the Notice of Termination consistent with SWRCB comments. The Notice of Termination must be accepted by the SWRCB prior to Contract Acceptance.

1.11 DUST CONTROL

A. The Contractor shall provide dust control at all times, including holidays and weekends, as required to abate dust nuisance or fugitive wind born particulates from the site due to construction activities or stockpiles. Dust and stockpile wind borne erosion control shall be by means of sprayed water or by other approved methods (eg. temporary hydraulic mulch, rolled erosion control products (RECPs)), polyacrylamide or straw mulch with tackifier. Chemicals, oil, or similar palliative shall not be used. Recycled water shall be used where available. Do not allow duct control activities to initiate non-storm water discharges of water, silt, or sediment into MS4s or other storm drains.

B. Quantities and equipment for dust control shall be sufficient to effectively prevent dust nuisance on and about the jobsite; and when weather conditions warrant, sprinklering equipment shall be on hand at all times for immediate availability.

C. The Engineer will have authority to order dust control work whenever conditions warrant, and there shall be no additional cost to the District therefor. Dust control shall be effectively maintained whether or not the Engineer orders such work.

D. Complaints from the public shall be reported to the Engineer and shall be acted on immediately.

E. Where earthwork operations are in progress, keep exposed earth surfaces dampened continuously. Also, keep dirt accessways and roads dampened continuously.

F. If portions of the site are temporarily inactive or abandoned for more than 14 Days, provide dust control and abatement continuously during such periods of inactivity.

G. Prohibit mud, dust, and particulates from construction activities from leaving the Jobsite by use of temporary construction entry-exits, tire washers, and/or stabilized construction roadways. Perform street sweeping activities as needed, with a commercial grade vacuum sweeper with rotating bristles and spray/fogger nozzles to remove off site tracking of mud, dirt or dust particulates. Do not use a motorized kick broom or water truck where MS4s or other storm drains may be deleteriously affected by silt, dirt or sediment incursion.

1.12 MUD CONTROL

A. The Contractor shall take proper measures to prevent offsite tracking of mud, dirt or sediment. Such measures shall include, but are not limited to, implementation of temporary construction entry-exits, stabilized construction roadway, or temporary entry-exit tire wash best management practices as outlined in the project WPCP or SWPPP BMP implementation manual.

B. All egress from the Jobsite shall be maintained in a dry condition, and any mud tracked onto streets, sidewalks, or drives shall be immediately removed, and the affected area shall be cleaned. The Engineer may order such work at any time the conditions warrant.

C. Where trucks will leave a muddy site and enter paved public streets, the Contractor shall maintain a suitable truck wheel-washing facility and crew. Before leaving the site, trucks and other vehicles, shall be cleaned of mud and dirt, including mud and dirt clinging to exterior body surfaces of vehicles.

D. All trucks coming to the jobsite or leaving the jobsite with materials or loose debris shall be loaded and covered in a manner that will prevent dropping of materials or debris on streets. Spillage resulting from hauling operations along or across any public traveled way shall be removed immediately.

1.13 NOISE CONTROL

A. Requirements: Minimize noise caused by construction operations, and provide working machinery and equipment fitted with efficient noise suppression devices. Employ other noise abatement measures as necessary for protection of employees and the public. In addition, restrict working hours and schedule operations in a manner that will minimize, to the greatest extent feasible, disturbance to residents in the vicinity of the Work.

B. Definitions:

1. Daytime refers to the period from 7:00 a.m. to 7:00 p.m. local time daily except Sundays and legal holidays.

2. Nighttime refers to all other times including all day Sunday and legal holidays.

3. Construction Limits are defined for the purpose of these noise control requirements as the District right-of-way lines, construction easement boundaries, or property lines as shown on the Contract Drawings.

4. Zones, Special Zones, and Special Construction Sites outside of the Construction Limits shall be as designated by the local authority having jurisdiction. Such specially designated zones shall be treated by the Contractor as if they were within the Construction Limits.

C. Monitoring:

1. Monitor noise levels of work operations to assure compliance with the noise limitations specified herein. Retain record of noise measurements for inspection by the Engineer.

2. Promptly inform the Engineer of any complaints received from the public regarding noise. Describe the action proposed and the schedule for implementation, and subsequently inform the Engineer of the results of the action.

3. Monitor noise levels day and night and for each new activity or piece of equipment. Start by measuring three times a day plus once a night for three consecutive days. Monitor noise levels at least once a week thereafter.

D. Measurement Procedure:

1. Except where otherwise indicated, perform all noise measurements using the A-weight network and “slow” response of an instrument complying with the criteria for a Type 2 General Purpose sound level meter as described in ANSI S1.4.

2. Measure impulsive or impact noises with an impulse sound level meter complying with the criteria of IEC 179 for impulse sound level meters. As an alternative procedure, a Type 2 General Purpose sound level meter on C-weighting and "fast" response may be used to estimate peak values of impulsive or impact noises. Transient meter indications of 125 dbC "fast" or higher will be considered as indications of impulsive noise levels of 140 dbC or greater.

3. Measure noise levels at buildings affected acoustically by the Contractor's operations at points between three feet and six feet from the building face to minimize the effect of reflections.

4. Measure noise levels at points on the outer boundaries of Construction Limits or Special Construction Sites for noise emanating from within.

5. Where more than one criterion of noise limits is applicable, use the more restrictive requirement for determining compliance.

E. Continuous Construction Noise: Prevent noise from stationary sources, parked mobile sources, or any source or combination of sources producing repetitive or long-term noise lasting more than a few hours from exceeding the following limits:

1. Maximum Allowable Continuous Noise Level, dBA:

Affected Residential Area	Daytime	Nighttime
Single family residence	60	50
Along an arterial or in multi-family residential areas, including hospitals	65	55
In semi-residential/commercial areas, including hotels	70	60
Affected Commercial Area	**At All Times**	
In semi-residential/commercial areas, including schools	65	
In commercial areas with no nighttime residency	70	
Affected Industrial Area		
All locations	80	

F. Intermittent Construction Noise: Prevent noises from non-stationary mobile equipment operated by a driver or from any source of non-scheduled, intermittent, non-repetitive, short-term noises not lasting more than a few hours from exceeding the following limits:

1. Maximum Allowable Intermittent Noise Level, dBA:

Affected Residential Area	Daytime	Nighttime
Single family residence areas	75	60
Along an arterial or in multi-family residential areas, including hospitals	75	65
In semi-residential/commercial areas, including hotels	80	70
Affected Commercial Area	**At All Times**	
In semi-residential/commercial areas, including schools	80	
In commercial areas with no nighttime residency	85	
Affected Industrial Area		
All locations	90	

1.14 PROTECTION AND USE OF BART ELEVATORS AND ESCALATORS

A. BART elevators and escalators are not to be used for transporting materials, equipment, or debris during construction operations at any time, including non-revenue hours. Construction workers with tool belts and small hand tools may use escalators for access when approved by the Engineer in writing.

B. Escalators and elevators shall be protected from adjacent or overhead construction operations. If protection of an escalator requires the escalator to be removed from service during revenue hours, the removal from service must be approved by the Engineer in writing. Tarps may be used to protect escalators from falling dust and light debris. Prior to returning an escalator to service, the escalator shall be inspected for dust or debris and then operated for two complete revolutions of the escalator steps while the comb plate is observed for debris. If falling debris could damage the escalator, a wooden cover constructed of fire retardant treated lumber and plywood shall be used to protect escalators from falling debris. Such cover shall be designed to support all imposed debris loads.

PART 2 – PRODUCTS

Not Used

PART 3 – EXECUTION

Not Used

END OF SECTION 01 57 00

SECTION 01 58 00

PROJECT IDENTIFICATION

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Project identification signs.

B. General construction signs.

1.02 MEASUREMENT AND PAYMENT

A. Separate measurement or payment will not be made for work required under this Section. All costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work.

1.03 PROJECT IDENTIFICATION SIGNS

A. Requirements: Provide temporary project identification signs as indicated.

B. Location: Locate the signs as indicated or as designated by the Engineer. Additional identical signs, as desired and paid for by the Contractor, may be placed at intermediate points if first approved by the Engineer. Place no other signs on the right-of-way or within the limits of the jobsite.

1.04 GENERAL CONSTRUCTION SIGNS

A. Requirements: Provide temporary general construction signs and field office identification signs as indicated or required. Provide field office identification signs for both the Engineer's field office and the Contractor's field office.

B. Design, Layout, and Size: Design, layout, style of lettering, and colors shall be as shown on the Contract Drawings.

1. General construction signs shall be constructed from a sheet of plywood four feet by eight feet or three feet by six feet in size, as appropriate for the location, mounted on two posts set in the ground.

2. Field office signs shall be of similar design, three feet by six feet in size, for wall or post mounting, as appropriate for the location.

C. Location: Locate the signs as indicated or as designated by the Engineer.

1.05 CONSTRUCTION AND INSTALLATION

A. Materials: Sign faces shall be constructed of 3/4-inch thick, five ply, exterior grade, A-B-faced, Douglas-fir plywood, APA-grade-stamped. The frame shall be nominal

two by two or two-by four stock, either construction-grade Douglas fir or A-grade redwood. Posts shall be four by six construction-grade Douglas fir, pressure-preservative-treated, eight to 12 feet long as required for the location.

B. Construction: Plywood signs shall be let into the frame, and the frame corners shall be mitered and screwed together. The sign shall be screwed to two, two by six Douglas-fir cleats that shall be bolted to the posts with at least two 1/4-inch bolts per post.

C. Installation: Sign posts shall be installed in the ground three feet deep, with the top of the sign horizontal, level, and even with the top of the posts, seven feet minimum above the ground.

D. Painting: Signs shall receive one coat of primer sealer and two base coats of exterior semi-gloss enamel. Generally, letters and logos shall be painted black or BART blue on a white background. Style of letters shall be Helvetica, unless otherwise indicated.

E. Maintenance: Keep signs clean and in good repair until Substantial Completion of the Contract.

F. Sign Quantities: Quantities of signs required are shown on the Contract Drawings.

PART 2 – PRODUCTS

Not Used

PART 3 – EXECUTION

3.01 CLOSEOUT

A. Upon completion of the Work, the signs shall be left in place or shall be removed and disposed of off the District's property, as determined by the Engineer.

END OF SECTION 01 58 00

SECTION 01 60 00

PRODUCT REQUIREMENTS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Quality of materials.

B. VOC regulations.

C. Appurtenances and accessories.

D. Packaging and handling.

E. Transportation and delivery.

F. Storage and protection.

G. Material safety data sheets.

1.02 MEASUREMENT AND PAYMENT

A. Separate measurement or payment will not be made for work required under this Section. All costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work.

1.03 QUALITY OF MATERIALS

A. Materials, equipment, appliances, fixtures, and fabricated assemblies to be incorporated in the Work shall be new, except as may be indicated or specified otherwise in the Contract Documents.

B. Materials, equipment, assemblies, and systems shall be manufactured, fabricated, handled, and incorporated into the Work so as to ensure completed work meeting the Contract requirements.

C. Additional quality assurance provisions for materials and equipment are specified in Section 01 43 00, Quality Assurance.

D. Additional Requirements are included in General Conditions Article GC6, Control of Materials.

1.04 VOC REGULATIONS

A. Materials shall comply with the current, applicable regulations of the Environmental Protection Agency (EPA), The California Building Standards Commission (including all standards referenced in the California Green Building Standards Code

(CalGreen), California Air Resources Board (CARB), and the Bay Area Air Quality Management District governing permissible content of volatile organic compounds (VOC). Refer to Section 01 81 13, Sustainability Requirements, for additional information on VOC requirements for products.

1.05 APPURTENANCES AND ACCESSORIES

A. Products to be incorporated in the Work shall be furnished as complete assemblies or systems with all appurtenances and installation anchors, fasteners, and accessories as required to provide a complete and finished product installation.

B. Installed products with moving parts shall be fully operable at proper settings and levels in accordance with the respective manufacturers' instructions and recommendations.

1.06 PACKAGING AND HANDLING

A. Avoid bending, scraping, or overstressing materials and equipment. Protect projecting parts by blocking with wood, by providing bracing, or by other approved methods.

B. Materials and equipment shall be protected from soiling and moisture by wrapping or by other approved methods.

C. Small parts shall be packaged in containers such as boxes, crates, or barrels to avoid dispersal and loss. Firmly secure an itemized list and minimize construction waste associated with packaging as specified in Section 01 81 13, Sustainability Requirements description of contents to each such container.

1.07 TRANSPORTATION AND DELIVERY

A. Arrange deliveries of materials and equipment in accordance with the Detailed Project Schedule specified in Section 01 32 16, Construction Progress Schedule, and coordinate to avoid conflict with work and conditions at the site.

B. Deliver materials in undamaged condition, in manufacturers' original containers or packaging (where applicable), with identifying labels intact and legible.

C. Deliver cement, prepared dry mortar mixes, grouting material, plaster, and coloring material in original, unopened and sealed containers, bearing the brand and manufacturer's name.

D. Refer also to the individual Specifications Sections for detailed requirements as applicable.

1.08 STORAGE AND PROTECTION

A. The receiving, storage, quality, and inventory control of equipment and materials required for the Work of this Contract shall be the sole responsibility of the

Contractor. Arrange storage to provide easy access for inspection and identification of each shipment.

B. Store materials in such a manner as to ensure the preservation of their quality and fitness for the work and to facilitate inspection.

C. Provide sheltered, weathertight, or heated weathertight storage as required to protect materials and equipment from weather damage and corrosion.

D. Store manufactured materials in accordance with the various manufacturers' instructions, with seals and labels intact and legible. Maintain temperature and humidity within the ranges required by the various manufacturers' instructions.

E. Provide blocking, platforms, pallets, or skids for materials and equipment subject to damage by contact with earth or pavement. Provide clearances from adjacent surfaces for stored materials requiring natural ventilation.

F. Store packaged materials in their original unbroken packages or containers.

G. Protect materials and equipment from damage and corrosion during warehousing operations.

H. Perform periodic inspections of stored materials to assure that materials are maintained under specified conditions, and are free from damage or deterioration.

I. Continue protection of materials and equipment from damage and corrosion after installation until final acceptance of the Work.

J. Refer also to the individual Specifications Sections for detailed requirements, as applicable.

1.09 MATERIAL SAFETY DATA SHEETS (MSDS)

A. The Contractor shall furnish MSDS for all materials to be incorporated in the Work. A file drawer or drawers shall be provided in the Contractor's field office (or other acceptable location) for the filing of all MSDS. MSDS shall be filed in accordance with Specifications' Section numbers, and shall be readily available to the Engineer, jurisdictional inspection authorities, and all personnel engaged in the Work.

B. MSDS for material that are flammable or otherwise hazardous shall be posted on a bulletin board provided for this specific purpose. This bulletin board shall be located at the site, sheltered from rain and wind, and shall be readily accessible to all personnel engaged in the Work. Refer to Section 01 81 13, Sustainability Requirements for additional product submittal requirements related to Sustainability Information.

PART 2 – PRODUCTS

Not Used

PART 3 – EXECUTION

Not Used

END OF SECTION 01 60 00

SECTION 01 64 13

DISTRICT- FURNISHED MATERIALS (DFM) AND

DISTRICT-FURNISHED EQUIPMENT (DFE)

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. District-furnished materials and District-furnished equipment.

B. Delivery, storage and handling.

C. Installation facilities, tools and materials.

D. Installation instructions and supervision.

1.02 RELATED SECTIONS AND DOCUMENTS

A. Refer to Section 01 60 00, Product Requirements, for handling, storage, and other pertinent requirements.

B. General Conditions Article GC6.2 District-Furnished Materials (DFM) and District-Furnished Equipment (DFE).

1.03 MEASUREMENT AND PAYMENT

A. Measurement: Installation of District-furnished materials and District-furnished equipment will be measured for payment as a lump-sum unit, acceptably stored and installed.

B. Payment: Installation of District-furnished materials and District-furnished equipment will be paid for at the Contract lump-sum price indicated in the Bid Schedule of the Bid Form.

1.04 ABBREVIATIONS

A. District-furnished materials may be referred to herein and in other Sections of the Contract Specifications, where applicable, by the abbreviation DFM.

B. District-furnished equipment may be referred to herein and in other Sections of the Contract Specifications, where applicable, by the abbreviation DFE.

1.05 DISTRICT-FURNISHED MATERIALS AND DISTRICT-FURNISHED EQUIPMENT

A. The materials and equipment to be furnished by the District for installation by the Contractor are specified in the Contract Specifications, Section 01 64 13, District-Furnished Materials (DFM) and District-Furnished Equipment (DFE).

1.06 CONTRACTOR'S RESPONSIBILITIES

A. Requirements: The Contractor shall assume custody of, and provide protection for, all District-furnished materials and District-furnished equipment from delivery and acceptance by the Contractor until Substantial Completion of the Work and the return of any excess materials and equipment.

B. Protection: Protect all District-furnished materials and District-furnished equipment while in custody from theft, vandalism, loss, and damage during unloading, storing, handling, distributing, and installing the materials and equipment. Lost or damaged materials and equipment, as documented by the District, shall be replaced by the Contractor at no additional cost to the District.

C. Delivery Schedule:

1. District-furnished materials and District-furnished equipment will be delivered by the respective suppliers to the delivery sites indicated, within the dates indicated in the listing in the Contract Specifications, Section 01 64 13, District-Furnished Materials (DFM) and District-Furnished Equipment (DFE). District-furnished materials and District-furnished equipment will be delivered to the delivery sites between the hours of 7:00 a.m. and noon, Monday through Friday.

2. The method and rate of material delivery will be determined by the respective suppliers, and this information will be reported by the District to the Contractor at least two weeks prior to the initial delivery of each type of material.

3. All Contractor requests for modification to the delivery method, location, rate, or date(s) shall be made through the Engineer. Should an agreement be reached to modify any delivery parameter, all additional costs due to the modification shall be paid by the Contractor.

D. Unloading: The Contractor shall provide all labor, equipment, and materials necessary to unload, handle, stockpile, and store District-furnished materials and District-furnished equipment. The Contractor shall unload and stockpile or store all District-furnished materials and District-furnished equipment within four hours of their arrival at the delivery site. Unloading and handling shall be in accordance with the respective manufacturer's recommendations as furnished by the Engineer.

E. Storage Plan: Prepare a storage plan for each storage area where District-furnished materials and District-furnished equipment are proposed to be stored or stockpiled. The plan shall be in sufficient detail to demonstrate that efficient handling and security provisions have been provided, that supporting soils will not be overloaded, and that materials will not be overstressed due to bending or shear. Security provisions shall be in accordance with Contract Specifications, Section 01 35 33, Security Procedures. A running inventory of the materials on hand shall be provided and kept, and the Contractor shall notify the Engineer at least 30 Days in advance of any anticipated shortages.

F. DFM and DFE Acceptance: Inspect all District-furnished materials and District-furnished equipment at time of delivery by the respective suppliers to the delivery sites, and submit certification to the Engineer showing the quantity of accepted materials and equipment. Set aside all damaged materials and equipment, and immediately notify the Engineer and the delivery carrier in writing of the damage and circumstances of discovery.

G. Inventory Records: Prepare and maintain perpetual inventory records of District-furnished materials and District-furnished equipment, and assign stock number, date of receipt from the District, and approximate date of construction placement. All checkout and returns of District-furnished materials and District-furnished equipment or other transfer of materials and equipment between the Contractor and the District shall be accompanied by an inventory record form.

H. Excess Materials: Upon Substantial Completion of the Work, the Contractor shall transport, unload, and stockpile, all excess District-furnished materials and District-furnished equipment to a delivery location within a 50 mile radius of the jobsite, as determined by the Engineer.

1.07 INSTALLATION FACILITIES, TOOLS, AND MATERIALS

A. The Contractor shall furnish all facilities, tools, equipment, materials, and services needed to complete the installation of District-furnished materials and District-furnished equipment, and such other tools, equipment, materials, and services as required to complete the Work.

B. District-furnished materials and District-furnished equipment shall be installed accurately and efficiently to avoid waste, such as that due to incorrect or inaccurate installations. Wasted materials and equipment, as documented by the Engineer, shall be replaced by the Contractor at no additional cost to the District.

1.08 INSTALLATION INSTRUCTIONS AND SUPERVISION

A. The Engineer will provide the Contractor with installation instructions and drawings from the manufacturers of District-furnished equipment. In addition, the assembly, installation, and testing of the major and more complex items of mechanical equipment, electrical and electronic equipment, and communications and radio equipment shall be performed under the technical supervision of installation supervisors from the various manufacturers' organizations.

B. Installation supervisors’ services for District-furnished equipment will be obtained by and at the expense of the District, and the installation supervisor will be made available, insofar as possible, when needed by the Contractor.

C. The Contractor shall be responsible for coordinating the work and cooperating with the Engineer in scheduling the time when each installation supervisor will be needed in order to best conform with the installation and testing schedules and still allow sufficient advance notice to the manufacturer for scheduling the most suitable installation supervisor.

D. The Contractor shall be responsible for any work performed in the absence of the installation supervisor, or work that does not conform to such supervisor's instructions, and any resulting errors in assembly or installation shall be corrected by the Contractor without additional cost to the District.

E. The Contractor will not be held responsible for faulty manufacture of the equipment, for any errors in the manufacturers' assembly drawings, or for erroneous instructions issued by the installation supervisor.

PART 2 – PRODUCTS

Not Used

PART 3 – EXECUTION

Not Used

END OF SECTION 01 64 13

SECTION 01 71 13

MOBILIZATION

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Organization and mobilization of the Contractor's forces.

B. Transporting construction plant and equipment to the Jobsite and setting up of same.

C. Transporting various tools, materials, and equipment to the Jobsite.

D. Erection of temporary buildings and facilities as required for field offices, staging, storage, and construction operations.

1.02 RELATED SECTIONS

A. Refer to Section 01 51 00, Temporary Utilities, Section 01 52 00, Construction Facilities, Section 01 57 00, Temporary Controls, and Section 01 58 00, Project Identification for specific requirements, as applicable.

1.03 MEASUREMENT AND PAYMENT

A. Measurement: The work of this Section will not be measured separately for payment.

B. Payment: Mobilization will be paid for at the Bid Item lump sum price for mobilization, and will include accumulating tools, apparatus, equipment, materials, and personnel, and performing final removal and demobilization. The Bid Item lump sum price will be paid as follows:

1. Forty-five percent of the Bid Item lump sum price within 30 Days following the effective date of the Notice to Proceed.

2. Forty-five percent of the Bid Item lump sum price within 60 Days but no sooner than 30 Days following the effective date of the Notice to Proceed.

3. Ten percent of the Bid Item lump sum price after the Engineer has determined that the Contractor has left the Jobsite in a clean condition after the completion of all phases of work.

1.04 DESCRIPTION

A. Mobilization shall include mobilization of all construction equipment, materials, supplies, appurtenances, facilities, and the like, staffed and ready for commencing and prosecuting the Work; and the subsequent demobilization and removal from the Jobsite of said equipment, appurtenances, facilities, and the like upon completion of the Work.

B. Mobilization shall also include assembly and delivery to the jobsite of plant, equipment, tools, materials, and supplies necessary for the prosecution of work which are not intended to be incorporated in the Work; the clearing of and preparation of the Contractor's work area; the complete assembly, in working order, of equipment necessary to perform the required work; personnel services preparatory to commencing actual work; and all other preparatory work required to permit commencement of the actual work on construction items for which payment is provided under the Contract.

1.05 SUBMITTALS

A. Refer to Section 01 33 00, Submittal Procedures, for submittal requirements and procedures.

B. Submit a plan of the proposed layout of the construction site, including fences, roads, parking, buildings, staging, and storage areas, within seven Days after the effective date of the Notice to Proceed.

1.06 DELIVERY

A. Delivery to the jobsite of construction tools, equipment, plant, temporary buildings, materials, and supplies shall be accomplished in conformance with local governing ordinances and regulations.

1.07 TOOLS AND SUPPLIES

A. Provide construction tools, equipment, materials, and supplies of the types and quantities necessary to facilitate the timely execution of the Work.

B. Provide personnel, products, construction materials, equipment, tools, and supplies at the jobsite at the time they are scheduled to be installed or utilized.

1.08 PLANT LOCATION

A. Locate plant, or plants, appropriately close to the portion of the Work for which it will be used.

1.09 DEMOBILIZATION

A. Upon completion of the Work, remove construction tools, apparatus, equipment mobile units and buildings, unused materials and supplies, plant, and personnel from the Jobsite.

B. Restore all areas utilized for mobilization to their original, natural state or, when called for in the Contract Documents, complete such areas indicated.

PART 2 – PRODUCTS

Not Used

PART 3 – EXECUTION

Not Used

END OF SECTION 01 71 13

SECTION 01 71 23

FIELD ENGINEERING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Qualified services.

B. Lines and grades.

C. Survey of layout and performance.

D. Surveying accuracy and tolerances in setting survey stakes.

1.02 MEASUREMENT AND PAYMENT

A. Separate measurement or payment will not be made for work required under this Section. All costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work.

1.03 REFERENCES

A. Caltrans Division of Right-of-Way and Land Surveys, Office of Land Surveying, “Surveys Manual”.

B. Profession Land Surveyors Act, Business and Professions Code Sections 8762, 8771.

C. California Public Resources Code 8801-8819 and 8890-8902.

1.04 SUBMITTALS

A. Refer to Contract Specifications Section 01 33 00, Submittal Procedures, for submittal requirements and procedures.

B. Survey notes, drawings, and calculations shall be completed as the work progresses and one copy of each survey document shall be submitted to the District for record purposes.

C. Construction survey notes shall be provided to the Engineer within 48 hours after completion of the Contractor’s survey.

D. Submit maps showing all final centerline, station, and other Contractor-installed monumentation, properly prepared and submitted to the Engineer for approval.

E. The Contractor prior to construction shall comply with Business and Professions Code 8771 “Monuments”.

F. Results of surveys performed as specified herein.

1. List of spatial coordinates, both horizontal and vertical, of the measurements taken.

2. A Survey Control plan, at a scale no greater than one inch = 100 feet, depicting the results of the survey conducted.

G. Contractor shall incorporate the results of surveys conducted with the documents to be prepared, maintained, and submitted pursuant to Contract Specifications Section 01 78 39, Project Record Documents.

1.05 QUALIFIED SERVICES

A. Surveying services and field engineering services shall be performed under the direct supervision of a professional land surveyor or civil engineer currently licensed or registered in the State of California. A civil engineer providing field surveying shall have been registered prior to 1982 or have a current professional land surveyors license in the State of California.

1.06 LINES AND GRADES

A. Only such primary control lines, monuments, and bench marks will be set by the District as the District determines to be necessary to control establishment of the lines and grades required for completion of the Work. In general, these will consist of the primary horizontal and vertical control points indicated on the Contract Drawings. Work points shall be established by the Contractor for all major structures, all track alignments, and all roadway alignments. Survey monuments shall be set at each end of station platforms by the Contractor to establish platform finish elevations.

B. Primary control monuments set by the District shall be carefully preserved by the Contractor. In case such monuments are destroyed or damaged, they will be replaced at the District's earliest convenience. The Contractor will be charged for the cost of replacing or restoring monuments destroyed or damaged by the Contractor's operations. This charge will be deducted from any monies due or to become due the Contractor.

C. The Contractor shall temporarily suspend work at such points and for such reasonable times as the District may require for resetting monuments, and the Contractor will not be entitled to any additional compensation or extension of time therefore.

D. All other stakes or markers required to establish the lines and grades required for the completion of the Work shall be the responsibility of the Contractor.

1.07 SURVEYS FOR LAYOUT AND PERFORMANCE

A. Surveying Requirements: Perform all surveys for layout and performance of the Work, reduce the field notes, and make all calculations and drawings necessary to carry out such work. The Contractor shall check the relative positions of all

monuments and benchmarks to be used and shall report any damaged or out-of-position monuments to the Engineer at once. The Contractor shall check such relative positions each time the Contractor uses such monument or benchmark.

B. Datum: The Contractor shall be responsible for correctly locating all lines and grades and for performing all measuring as required for the construction and completion of the Work from established reference points and information is shown on the Contract Drawings.

C. Equipment and Personnel: The Contractor's instruments and other survey equipment shall be accurate, suitable for the surveys required in accordance with recognized professional standards, and in proper condition and adjustment at all times. Perform all surveys under the direct supervision of a professional land surveyor or civil engineer currently licensed or registered in the State of California.

D. Field Notes and Records: Furnish the original pages of all survey records to the District at intervals required by the District. Furnish each field notebook to the Engineer when filled or completed.

E. Use by the District: The District may at any time use line and grade points and markers established by the Contractor. The Contractor's surveys are a part of the work and may be checked by the Engineer at any time. The Contractor shall be responsible for any lines, grades, or measurements which do not comply with specified or proper tolerances, or which are otherwise defective, and for any resultant defects in the work. The Contractor shall conduct resurveys or check surveys to correct errors indicated by review of the field notebooks or by check surveys performed by the District.

1.08 SURVEYING ACCURACY AND TOLERANCES IN SETTING SURVEY STAKES

A. Contract Control Surveys

1. Contract survey control shall be verified, densified, and maintained as necessary for the duration of the Contract. Surveys performed to verify and establish Contract survey control shall meet Caltrans standards specified herein. Contract control surveys shall reliably establish the Contract datum locally by direct ties to a minimum of three horizontal and vertical monuments. Existing Contract control values and descriptions will be provided by the District.

2. Contract control surveys shall be performed using appropriate equipment and techniques. Measured values shall be of sufficient redundancy to establish realistic measurement error estimation at the 95 percent confidence level. Contract control surveys shall be adjusted using least squares adjustment software. Final adjustment listing shall incorporate differences from control "provisional" values, and a summary listing of any residuals. Any measured Contract control value discrepancies, which fall significantly outside these accuracy guidelines, shall be reported immediately to the Engineer.

B. Contract Survey Control Nominal Accuracy Requirements:

1. Use horizontal control, vertical control, and units in accordance with Caltrans Survey Manual Chapter 5 “Classifications of Accuracy and Standards” Figure 2-1B Proportional Accuracy.

2. Horizontal datum shall be in accordance with California Coordinate System per Public Resources Code Section 8801-8819.

3. Vertical datum shall be in accordance with California Orthometric Heights of 1988 per Public Resources Code Section 8890-8902.

C. Construction Staking Requirements:

1. Construction staking shall be performed in accordance with the specifications contained in the Caltrans Surveys Manual, Chapter 12, sections 12.3 through 12.5, regarding the staking tolerances and the placement and marking of construction stakes.

2. Construction survey accuracies shall be in accordance with the specifications of the Caltrans Surveys Manual, Chapter 5 and Figure 5-1A, therein.

3. Surveying activities shall comply with Construction Safety Section 01 35 24, to include “Roadway Worker Protection Safety” requirements, Caltrans Surveys Manual Chapter 2 “Safety”, and Caltrans Code of Safe Surveying Practices figure 2-1.

PART 2 – PRODUCTS

Not Used

PART 3 – EXECUTION

Not Used

END OF SECTION 01 71 23

SECTION 01 74 14

CLEANING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Cleaning and cleanup during construction.

B. Dust control.

C. Disposal of debris.

D. Final cleaning of station facilities and ancillary buildings.

E. Final site cleanup.

1.02 RELATED STECTIONS

A. Refer to Section 01 57 00, Temporary Controls, for basic mud control and dust abatement requirements.

B. Refer to Section 01 81 13, Sustainability Requirements, for required documentation submittals.

C. When demolition is involved, refer to Section 02 41 19, Selection Structure Demolition, as applicable, for additional dust abatement requirements.

1.03 MEASUREMENT AND PAYMENT

A. Separate measurement or payment will not be made for work required under this Section. All costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work.

1.04 CLEANING AND CLEANUP DURING CONSTRUCTION

A. The entire site of the Work, including the Contractor's work and storage areas, shall be kept in a neat, clean, and orderly condition at all times during the course of this Contract. The Engineer may, at any time during construction, order a general cleanup of the site as a part of the Work, and there shall be no additional cost to the District therefore. The Contractor shall provide general daily clean-up and disposal service for removal of waste, rubbish, trash, and debris away from the jobsite.

B. Perform cleaning of all facilities and ancillary buildings as required during construction to prevent accumulations of dust, dirt, soil, trash, and debris, so that a clean and safe working environment will be present at all times.

C. Walkways or designated pathways for authorized visitors shall be kept broom clean at all times. Walkways over exposed earth surfaces shall also be kept neat and free of pebbles and other obstacles to walking comfortably, equivalent to broom clean of paved surfaces.

D. The Contractor shall remove all graffiti placed during the course of the Work within the Contractor's enclosed secured areas at the work site. The Contractor shall remove the graffiti within 24 hours after its detection in these areas.

1.05 DUST CONTROL

A. Clean interior spaces prior to the start of finish painting and the application of other finishes, and continue cleaning as required until such work is completed.

B. Schedule operations to prevent dust and other contaminants, resulting from cleaning operations, from adhering to set or newly finished surfaces.

C. Also, schedule operations to prevent dust and other flying particles from contaminating sensitive train control equipment in Train Control Rooms. Enforce tight controls as required to provide absolute dust control and abatement in these areas.

1.06 DISPOSAL OF DEBRIS

A. Dispose of waste, trash, and debris in a safe, acceptable manner, in accordance with applicable laws and ordinances and as prescribed by authorities having jurisdiction. Bury no waste material and debris on the site. Burning of trash and debris on the site will not be permitted.

B. Location of disposal site for trash and debris and length of haul are the Contractor's responsibility.

1.07 FINAL CLEANING OF STATION FACILITIES AND ANCILLARY BUILDINGS

A. Prior to final inspection by the District, and after all construction work is essentially complete, thoroughly clean station facilities and ancillary buildings and structures, utilizing professional building cleaners where appropriate.

B. Items to be cleaned include all glass, doors, hardware, opening frames, grilles, trim, exposed non-ferrous metal surfaces, plastics, floor coverings, light fixtures and plates, plumbing fixtures and trim, and all finish surfaces throughout the construction.

C. Vacuum-clean where appropriate and remove all spots, smears, dust, debris, hand prints, and defacements of every sort, including those of vandals. Use commercial cleaning compounds where necessary.

D. Follow the recommendations of the manufacturers of the materials and items to be cleaned for all cleaning, polishing, and treatment such as waxing or sealing. Polish all stainless steel and other non-ferrous metal surfaces.

E. Clean permanent filters of the air-conditioning system and replace disposable filters of units operated during construction. Clean ducts, blowers, and coils if units were operated without filters during construction.

1.08 FINAL SITE CLEANUP

A. Prior to Final Inspection, thoroughly clean the entire site and put it into a clean and neat, acceptable condition. Remove from the site all construction waste and unused materials, dunnage, loose rock and stones, excess earth, and debris of any description resulting from the Work.

B. Hose down and scrub clean where necessary all pavement and paved walks.

C. Thoroughly remove mortar droppings from concrete slabs and pavement where they occur. Hose down and scrub clean all concrete flatwork and exposed vertical surfaces of concrete and masonry.

D. Free and clear all new and existing drainage systems.

E. Clean and protect all conduit openings.

F. Prior to Final Inspection, the Contractor shall remove all markings from streets, sidewalks, walls and other District and City infrastructure within the enclosed secured area at the work sites.

PART 2 – PRODUCTS

2.01 CLEANING PRODUCTS

A. Utilize cleaning products that meet the requirements of the Green Seal GS-37 standard or comply with the requirements and maximum VOC limits of Title 17, California Code of Regulations, Division 3, Chapter 1, Subchapter 8.5, Article 2, Regulation for Reducing VOC Emissions from Consumer Products.

B. Utilize janitorial paper products and trash bags that meet the minimum percentages of post-consumer recycled content and recovered content requirements of EPA's Comprehensive Procurements Guidelines.

PART 3 – EXECUTION

Not Used

END OF SECTION 01 74 14

SECTION 01 74 21

WASTE MANAGEMENT

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Waste management plan.

1.02 MEASUREMENT AND PAYMENT

A. Separate measurement or payment will not be made for work required under this Section. All costs in connection with the worked specified herein will be considered to be included with the related items of work in the Bid Schedule of the Bid Form, or incidental to the Work.

1.03 DEFINITIONS

A. "Conversion Rate" means the rate set forth in the standardized Conversion Rate Table approved by the Engineer for use in estimating the weight of materials identified in the Waste Management Plan.

B. "Divert" means to use material for any purpose other than disposal in a landfill or transfer facility.

C. "Good faith" shall be as defined by law.

D. "Recycling Service" means an off-site service that provides processing of material and diversion from landfill.

E. "Hauler" means the entity that transports construction and demolition debris to either a landfill or a recycling service.

1.04 SYSTEM DESCRIPTION

A. Performance Requirements: The requirements for diversion of construction and demolition debris from landfill shall in no case be less than that required by local regulations. The minimum percentages for diversion of construction and demolition waste shall be as follows, unless modified in Contract Specifications Section 01 74 21, Waste Management, on the basis of a waste characterization study for the Work:

1. Divert a minimum of 75 percent of construction waste from landfill.

2. Divert a minimum of 100 percent of steel, asphalt, concrete, and land-clearing waste from landfill and an overall minimum of 70 percent of remaining demolition waste from landfill.

B. Specific Requirements: Recycle magnetic ballasts and older fluorescent lamps containing poly-chlorinated biphenyls (PCBs) and other toxic chemicals in such a manner that potentially dangerous chemicals are safely reprocessed.

1.05 SUBMITTALS

A. Submit specified Waste Management Plan using written and graphic representation to indicate how waste will be diverted from landfills. See Section 01 81 13, Sustainability Requirements, for schedule of required Waste Management Plan submittals.

B. Submit certification from recycling services that are not listed in directories acceptable to the Engineer. Examples of directories acceptable to the Engineer are listed under the Article entitled “Quality Assurance” herein.

C. Submit reports in accordance with approved Plan.

1.06 QUALITY ASSURANCE

A. Regulatory requirements

1. Comply with the requirements of the jurisdictional authority. In instances where the requirements specified herein are more stringent than those of specified herein, comply with specified requirements.

2. Obtain approval of the Waste Management Plan by the jurisdictional authority before beginning on-site mobilization if such approval is mandated by the jurisdictional authority.

B. Recycling service company qualifications; any of the following:

1. Listed in the City of Oakland, “Directory of Recycling Services for Construction and Demolition Material".

2. Listed in the Alameda County Waste Management Authority’s “Builders’ Guide to Reuse and Recycling, A Directory for Construction and Demolition Materials.

3. Listed in Central Contra Costa Solid Waste Authority’s, “Builder’s Guide”.

4. Any recycling services that will certify in writing that accepted waste will be diverted from landfill, not dumped illegally, and not dumped at sea.

1.07 WASTE MANAGEMENT PLAN

A. Plan Development: Develop a plan for diverting the specified percentage of construction debris from landfill. Include in plan either or both written and graphic information to indicate how waste will be diverted from landfills.

1. Submit and discuss the plan at or before the pre-construction meeting.

2. Propose means and methods for collecting and separating each type of debris deemed reusable or recyclable.

3. Identify the off-site recycling service and hauler of each designated debris item, who have agreed to accept and divert that item from landfill, in the proposed quantities anticipated. Schedule each item and list off-site recycling service and hauler company name, telephone number, address, and person contacted.

4. Include a "good faith" estimate of each type of construction waste that would be generated if no diversion methods were implemented. Submit with calculations based upon weight of each material. The following items are subject to the "good faith" estimate and diversion requirement:

    a. Asphalt concrete

    b. Portland cement concrete

    c. Brick, clay products and ceramic tile

    d. Aggregate

    e. Clean earth fill

    f. Metals

    g. Wood products, including pallets

    h. Plant and tree trimmings, may be included in wood products if so accepted by recycling service.

    i. Gypsum board

    j. Latex paint (not applicable to demolition work)

    k. Plastic piping

    l. Glass, excluding that used for containers

    m. Insulations

    n. Acoustical ceiling tiles, panels and boards

    o. Resilient floorings

    p. Carpets, and polyurethane foam pads (other types of pads may be included if accepted by recycling service)

    q. Cardboard and paper products

    r. Other, depending on anticipated waste.

5. Calculate quantities, and convert volume measurements to weights in accordance with the defined Conversion Rate.

B. Plan Implementation

1. Maintain log of each load, of each category item diverted from landfill. Log in separately debris sent to a Class III landfill and materials sent to recycling facilities.

   a. Include in log, type of load, load weight, name of hauling service; recycling service or landfill, and date accepted by recycling service or by landfill.

   b. The Engineer reserves the right to audit the log at any time, retain and make available, all weight tickets, copies of receipts and invoices.

   c. Units of measure: Use same units as stated in the approved plan "good faith" estimate of construction waste that would be generated if no remedial methods were implemented.

2. Material handling

   a. Separation facilities

      1) Designate a specific on site area or areas to facilitate separation of materials for potential reuse, salvage, recycling, and return.

      2) Keep waste bins and pile areas neat and clean. Clearly mark bins for each category of waste. Do not commingle non-recyclable waste with materials designated for reuse or recycling.

   b. Environmental controls during handling, storage, or transport: Do not permit designated materials to become contaminated or to contaminate site or surrounding areas.

3. Training and coordination

   a. Furnish copies of the Waste Management Plan to all on-site supervisors, each subcontractor, and the Engineer.

   b. Instruction: Provide on-site instruction of appropriate separation, handling, and recycling, salvage, reuse, and return methods to be used by all entities at the appropriate stages of the Work.

   c. Meetings: Include construction waste management on the agenda of meetings. At a minimum, discuss waste management goals and issues at the following meetings:

      1) Pre-construction meeting.

      2) Regularly scheduled job-site meetings.

C. Hazardous waste: Separate hazardous waste. Store and dispose of according to Contract requirements and local regulations.

PART 2 – PRODUCTS

Not Used

PART 3 – EXECUTION

Not Used

END OF SECTION 01 74 21

SECTION 01 77 00

CLOSEOUT PROCEDURES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Requirements preparatory to final inspection.

B. Final inspection.

C. Acceptance of the Work and final payment.

1.02 MEASUREMENT AND PAYMENT

A. Separate measurement or payment will not be made for work required under this Section. All costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work.

1.03 REQUIREMENTS PREPARATORY TO FINAL INSPECTION

A. The Contractor shall request a preliminary final inspection to determine the state of completion of the Work.

B. The request shall be made in writing, addressed to the Engineer, at least seven Days in advance of the requested date of the preliminary inspection.

C. The Engineer will perform the preliminary inspection within three Days of the requested date.

D. Prior to the requested date of the preliminary inspection, the Contractor shall perform or provide the following, as applicable:

1. Temporary facilities, except as may be required for punch list work, shall be removed from the site.

2. The site and all applicable appurtenances and improvements shall be cleaned as specified in Section 01 74 14, Cleaning.

3. Record drawings and specifications shall be completed, signed, and submitted to the Engineer as specified in Section 01 78 39, Project Record Documents.

4. Operating instructions for equipment shall be properly mounted and posted as specified in Section 01 78 23, Operation and Maintenance Data.

5. Guaranties and warranties shall be submitted to the Engineer, as specified in the General Conditions and various sections of the Specifications, along with required operations and maintenance manuals as specified in Section 01 78 23, Operation and Maintenance Data.

E. The Contractor shall be represented by its principal superintendent and such Subcontractors and Suppliers as may be necessary to answer the questions of the Engineer's inspection team.

F. Certain elements of the Work, such as mechanical and electrical work, may be scheduled separately at appointed times in order to keep the preliminary inspection more focused and the number of persons in the Engineer’s inspection team to a minimum.

G. From the information gathered from this inspection, the Engineer will prepare a punch list of work to be performed, corrected, or completed.

H. All work on the punch list shall be completed by the Contractor prior to requesting the final inspection.

1.04 FINAL INSPECTION

A. When all requirements of the above prepared punch list have been completed, the Contractor shall request the final inspection to determine eligibility for issuance of the Certificate of Substantial Completion.

B. The request shall be made in writing, addressed to the Engineer, at least seven Days in advance of the requested date of the final inspection.

C. The Contractor shall be represented by its principal superintendent and such Subcontractors and Suppliers as may be necessary to verify the completion of the Work including punch list items.

D. Depending on the extensiveness of the punch list items, certain elements of the Work may be scheduled separately for final inspection at appointed times.

E. If the Work has been substantially completed in accordance with the Contract Documents, and only minor corrective measures are required, the Engineer will recommend that the District issue a Certificate of Substantial Completion, based upon the Contractor's assurance that remaining corrective measures will be completed within the shortest practicable time period. The Engineer will attach a corresponding punch list to the Certificate of Substantial Completion. A fixed schedule for such corrective measures shall be submitted to the Engineer, for approval.

F. If the Work has not been substantially completed in accordance with the Contract Documents, and corrective measures are still required, a new punch list will be prepared by the Engineer, based on the information gathered from the final inspection, and the Contractor will be required to complete this work and then call for another final inspection, following the procedure outlined above.

G. The date of the Certificate of Substantial Completion will establish the completion date of the Work, or portions thereof as specifically referenced in the Certificate, for determining liquidated damages.

1.05 ACCEPTANCE OF THE WORK AND FINAL PAYMENT

A. Upon completion of the Substantial Completion punch list items, the Engineer will recommend that the District formally accept the Work.

B. Acceptance of the Work will be made in accordance with Article GC5.14 of the General Conditions. Final payment will be made in accordance with Article GC9.8 of the General Conditions.

PART 2 – PRODUCTS

Not Used

PART 3 – EXECUTION

Not Used

END OF SECTION 01 77 00

SECTION 01 78 23

OPERATION AND MAINTENANCE DATA

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Post Operating Instructions.

B. Operation and Maintenance (O&M) Manuals.

C. Off-the-Shelf Equipment Manuals.

D. System Manuals.

E. Asset Register.

1.02 RELATED SECTIONS

A. Requirements related to spare parts, maintenance materials, keys, special tools, and test equipment are specified in Section 01 78 44, Spare Parts and Maintenance Materials.

B. Training manuals required for classroom and on-site instruction and training are specified in Section 01 79 00, Demonstration and Training.

1.03 MEASUREMENT AND PAYMENT

A. Separate measurement or payment will not be made for work required under this Section. All costs in connection with the work specified herein will be considered included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work.

1.04 REFERENCES

A. American Society of Mechanical Engineers (ASME):

1. ASME Y14.5 Dimensioning and Tolerancing

B. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE 315 Graphic Symbols for Electrical and Electronic Diagram (Including Reference Designation Class Designation Letters)

C. BART Facilities Standards, Appendices, District Technical Manuals:

1. Contract Drawing CADD Requirements (available from the Engineer upon request).

2. Operation and Maintenance Manual Requirements (available from the Engineer upon request).

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, for submittal requirements. Schedule submittal of manuals in coordination with other submittals for the subject system or equipment.

B. Operating instructions for posting.

C. Outline of O&M manuals: Submit no later than 12 Days after equipment design approval. Include table of contents or layout, volumes, sections and headings, list of figures, list of tables, list of drawings.

D. Draft O&M manuals: Submit prior to delivery of equipment. Submit one hard copy and one electronic copy.

E. Prefinal O&M manuals: Submit no later than 42 Days prior to training. Submit one hard copy and one electronic copy.

F. Final O&M manuals:

1. Schedule: Submit final manuals no later than 42 Days following the satisfactory completion of acceptance tests for the subject system or equipment.

2. Submit one set of hard copy for District's O&M use.

3. Submit one set of electronic copy.

G. Asset Register: Submit 90 Days before Substantial Completion.

1.06 MANUAL HARD COPY REQUIREMENTS

A. Binder Specifications:

1. Binder: Durable, white, three-ring that accommodates standard three-hole punching, with clear plastic slip-in exterior pockets for cover and spine. Binder shall be sized for letter sized paper and sized to fit volume with space for additional pages. Maximum binder size is 3-inch capacity; larger sizes may be approved at the discretion of the District.

2. Sheet lifters: Provided at front and back of binder.

3. Paper: 24 lb bond grade, 8 1/2 by 11 inch or 11 by 17 inch. 11 by 17 inch sheets shall be fan-folded.

4. Binder tab dividers: Commercially purchased white dividers with tabs, with five tabs per bank, provided before each chapter including the table of contents. Label tabs by chapter title.

B. Front Cover and Spine:

1. Include District artwork for front cover and spine. Artwork for front cover shall include the project name, title of the manual, book number, and volume number if warranted as well as display “San Francisco Bay Area Rapid Transit District” and the District’s headquarter address in the lower center of the cover.

2. Artwork for the spine shall include the project name, title of the manual and book number.

3. Cover and spine shall be printed on white cardstock paper.

C. Divider Page: Each chapter including the table of contents shall have divider tabs.

D. Content of pages shall not be obstructed when printed, hole-punched, and assembled for hard copy.

E. Assembly: Printed out, assembled, and placed in binders.

1.07 MANUAL ELECTRONIC COPY REQUIREMENTS

A. Electronic manuals (e-Manuals) shall be in .pdf file format created from the native electronic files.

B. Electronic submission of manual shall include:

1. System Manuals: One USB drive or link to electronic file storage of native and .pdf files of the submitted manual. Native and .pdf files will be assembled in separate folders.

2. Off-the-Shelf Manuals: One USB drive or link to electronic file storage of native and .pdf files of the submitted manual.

3. Electronic files shall include a matrix or document showing how the files are set up and how to access them.

4. The content of files, native and pdf shall be identical to hardcopy manual submitted to District. Manuals shall be submitted as one .pdf file. Manual shall include identical front cover as hard copy. Native files shall have required formatting intact.

5. Extraneous files or information shall not be submitted with or incorporated in manuals.

C. The native electronic file formats are the programs used to create manual.

D. Text pages shall be created using the latest release of MS Word in use by the District at the time of the Contract award or compatible program.

E. Tables shall be created using the latest release of MS Excel in use by the District at the time of Contract award or compatible program.

F. Illustrations and drawings, including technical illustrations, shall be created using AutoCAD 2014 or the latest release in use by the District at the time of Contract award or compatible program.

G. Text pages containing illustrations shall have files inserted into the file as an object. Illustrations shall have a white background.

H. File table of contents shall have bookmarks or hyperlinks.

PART 2 – PRODUCTS

2.01 POSTED OPERATING INSTRUCTIONS

A. Provide printed sheets under framed clear acrylic plastic, giving brief, concise operating and maintenance instructions for items of mechanical and electrical equipment and similar equipment and specialty items, as applicable, at their respective locations.

2.02 OPERATION AND MAINTENANCE MANUALS

A. Furnish manuals for equipment and systems furnished or installed under Contract that require maintenance, operation, or modification including testing and training equipment. Furnish manuals for other items, such as finishes, when specified in the Contract Specifications. Furnish manuals for each item of equipment and its component parts.

B. Manual shall be formatted pursuant to BFS Appendix Operation and Maintenance Manual requirements.

C. Furnish manuals in one of the three following formats:

1. Off-the-shelf equipment manuals shall be furnished for off-the-shelf items. Such equipment includes sub-assemblies and components that are replaced instead of repaired or has no need for modifications, drawings, or manual revisions.

2. System manuals shall be furnished when stipulated in the Contract Specifications. Such systems and equipment include systems and equipment that have specifically built for District and require repairs and modifications beyond the scope of the manufacturer’s pre-existing operation and maintenance instructions. System manuals shall be District specific and not include copies of manufacturer’s operation and maintenance instructions and catalog cuts. Submit manufacturer’s operation and maintenance instructions, if required, separately.

3. Elevator manuals containing manufacturer’s operation and maintenance instructions and catalog cuts are acceptable provided the manuals meet the technical content requirements set forth for system manuals in addition to the requirements specified for off-the-shelf equipment manuals.

D. Creation of alternative manual formats shall not be accepted.

E. Manuals shall be written in English, legible, organized, free of spelling and grammatical errors.

F. Manuals shall be subject to revisions, updates and other alterations at the District's discretion.

G. The first section of each volume or book shall contain the cover sheet for that volume/book, the BART Configuration Control Record for that volume/book and the master Table of Contents listing all the chapters for the entire volume/book. When a volume is contained in more than one binder, each binder shall include a cover sheet, and master Table of Contents for the entire volume/book.

H. Paginate pages of manual by chapter-section-page or chapter-page format.

2.03 OFF-THE-SHELF EQUIPMENT MANUALS

A. Manuals shall consist of manufacturer's operating instructions and other operation and maintenance information available from the manufacturer.

B. Manuals shall include manufacturer's catalog cuts with specific items bubbled or clearly marked with arrows.

1. When it would be clearer to cross-out irrelevant portions of a page, neatly cross-out irrelevant information. Handwritten notes are not accepted. Notes shall be typewritten and inserted into the file or added to the manual's appendix.

2. Manuals shall include the following, as applicable and as required by the Engineer:

   a. Table of contents that reflects volumes, chapters, sections, procedure numbers, list of figures, list of tables, list of drawings, warranty information and corresponding page numbers.

   b. Catalog pages.

   c. Manufacturer's pre-printed maintenance and operations instructions.

   d. Wiring diagrams.

   e. Parts lists.

   f. Warranty slips.

   g. Manufacturer's certificates, as applicable and as required by the Engineer.

C. Manuals for HVAC, plumbing, and fire protection equipment shall list the following information:

1. Equipment identification.

2. Make and model.

3. Location of equipment.

4. Filter sizes and quantities.

5. Service and dealer directory including the authorized dealer name, phone number, address, email address, and web site for each piece of equipment.

6. Valve directory including the valve number, type, size, location and function.

7. Damper certification and verification.

8. Domestic water system cleaning and disinfection test results and report.

9. Air and water system balance reports.

10. Controls operation and maintenance data with wiring diagrams.

11. Approved seismic restraint inspection report, certified by professional licensed seismic engineer, or approved representative.

12. Warranties: Include effective date, expiration date, extent of warranty, name and contact information of firm providing warranty.

2.04 SYSTEM MANUALS

A. Manual shall meet the following requirements:

1. Developed in conjunction with maintainability requirements.

2. Organized so that each major subsystem is treated as an integrated system and not as a grouping of disassociated parts.

3. Contain data required to maintain equipment during equipment service life.

4. Contain data required to operate and maintain test equipment during equipment service life.

5. Contain no extraneous information, such as general communications, advertisements or company or manufacturer’s logos. Any reference to the manufacturer or Contractor, other than necessary references to the equipment in the text, is considered advertisement. Manufacturer or Contractor’s name shall not appear on binder covers or in the page titles, headers, footers or anywhere else in the document.

6. Contain all operating instructions. If required, provide a separate operating manual.

7. Contain drawings and illustrations that include necessary details for the installation, maintenance, and repair of equipment provided.

B. Numbering and Content Minimum Requirements:

1. Manual shall be composed of one or more volumes titled and organized by subject matter.

   a. Each volume may be contained in one or more binders, if necessary, and shall be designated accordingly (i.e., Volume 1A, Volume 1B, Volume 1C, etc.).

   b. Manuals for complex, multi-component systems may be organized into volumes with each volume covering a subsystem or component of the greater system. Multiple volumes shall be used when specified in the Contract Specifications, when required by the Engineer, or when proposed by the Contractor and accepted by the Engineer.

2. Each volume shall be consecutively numbered (i.e. Volume 1, Volume 2, Volume 3, etc.)

C. Manual (or volume in the case of multi-volume manuals) shall be organized into nine specific chapters as outlined herein.

1. Chapter 1 – General Information and Specification

2. Chapter 2 – Theory of Operation

3. Chapter 3 – Troubleshooting

4. Chapter 4 – Primary Repair

5. Chapter 5 – Secondary Repair (Component Level)

6. Chapter 6 – Preventive Maintenance

7. Chapter 7 – Illustrated Parts Catalog

8. Chapter 8 – Miscellaneous

9. Chapter 9 – Wiring Diagrams

D. Include table of contents. Table of contents shall reflect procedure numbers, figure numbers, tables numbers and corresponding page numbers, and the volumes, chapters, and sections of each manual, as applicable. Table of contents shall list and contain the following:

1. Chapter titles

2. Section titles

3. Sub-section titles and corresponding page numbers

4. List of drawings, including titles, numbers and corresponding page numbers

5. List of figures, including figure titles, figure numbers and corresponding page numbers

6. List of tables, including titles, numbers, and corresponding page numbers

7. Procedure numbers and corresponding page numbers

8. Related media

E. Each chapter shall have a table of contents which include the following:

1. Section titles

2. Sub-section titles and corresponding page numbers

3. List of drawings, including titles, numbers, and corresponding page numbers

4. List of figures, including figure titles, figure numbers and corresponding page numbers

5. List of tables, including titles, numbers, and corresponding page numbers

6. Procedure numbers and corresponding page numbers

F. Chapters shall comply with the following requirements:

1. Chapter 1 – “General Information and Specifications”, shall provide a general overview of the system, including:

   a. A “List of Acronyms and Abbreviations” in the form of a table.

   b. General non-technical description of equipment, including interface relationships and general functions.

   c. Pictorial views of the subassembly components and parts described.

   d. Tables listing the performance specifications of equipment.

2. Chapter 2 – “Theory of Operation”, shall provide a technically detailed description of equipment, by subsystem, including:

   a. Location of parts in subassembly or component being discussed.

   b. Location, function, and operation of pertinent controls, gauges, indicators, and switches.

   c. Subsystem setup and shutdown procedures.

d. Trouble symptoms and first-response diagnostic methods.

e. Emergency procedures and safety requirements.

f. Electrical wiring diagrams, electronic schematics, and mechanical configurations.

g. Block diagrams of provided subsystems signal flow diagrams, including interface connections to other subsystems.

h. Applicable charts, figures, and drawings to be located at the end of text for each subsystem.

3. Chapter 3 – “Troubleshooting”, shall contain:

a. Necessary information for troubleshooting and fault isolation.

b. Charts and tables as applicable listing symptoms, probable causes of improper operation or failure of subsystem and probable remedies.

4. Chapter 4 – “Primary Repair”, shall contain the following information to allow maintenance to be performed at equipment location site:

a. Detailed corrective maintenance procedures to be performed on equipment shall include particulars on testing alignment, adjustment and tuning. Include detailed views of mechanical parts or schematics for tests.

b. Step-by-step procedures of installation and removal of components and subassemblies (field replaceable units).

c. Procedures for use of special test equipment.

d. Warning and caution notes as required.

e. Applicable charts, figures, and drawings to be located at the end of text for each subsystem.

5. Chapter 5 – “Secondary (Component) Repair”, shall contain the following regarding maintenance to be performed in a shop other than the equipment location site:

a. Detailed corrective maintenance procedure to be performed on subassemblies and components shall include particulars on testing alignment and tuning. Include detailed views of mechanical parts or schematics.

b. Step-by-step procedures for installation and removal of parts in assemblies and components.

c. Procedures for use of special test equipment.

d. Incorporate warning and caution notes, as required.

e. Applicable charts, figures, and drawings to be located at the end of text for each subsystem.

6. Chapter 6 – “Preventive Maintenance”, shall contain:

    a. Preventive maintenance procedures, schedules, and tables including lubrication requirements and frequency of application.

    b. Inspection and maintenance standards, including wear limits, settings, tolerances, and criticality of tolerances.

    c. Storage instructions for spare parts, special tools and test equipment.

7. Chapter 7 – “Illustrated Parts Catalog”, shall contain:

    a. Instructions for use of Illustrated Parts Catalog.

    b. Index by subassembly.

    c. Illustrations which are exploded views of assemblies, components, and parts with leader lines and circled callout numbers to each item.

    d. Detailed Parts List, including:

        1) Figure Number.

        2) Part index number, not to exceed 19 alphanumeric characters.

        3) Space to allow for insertion of the District’s nine-digit stock number (group, subgroup, part number).

        4) Description of part, including manufacturers and vendor’s part number.

        5) Equivalent parts available from other manufacturers.

        6) Disposition of part (repairable, non-repairable, etc.)

        7) Quantity required per assembly.

8. Chapter 8 – “Miscellaneous”, shall contain information that is deemed inappropriate for any other chapter including descriptive brochures, manufacturer’s certificates, and warranty slips.

9. Chapter 9 – “Wiring Diagrams”, shall contain:

    a. Applicable electrical, electronic, pneumatic, and schematic diagrams.

    b. Wiring diagrams, including wire color code, size, and rating; terminal and connector pin numbers; and plug and socket numbers.

    c. Pin-to-pin description of each wire, using wire-marking format. Additionally, wires at each terminal block and each connector shall be independently identified and cross-referenced at the next terminating point.

    d. Diagram size in accordance with that previously stated in these specifications.

    e. PCB layout diagrams (artwork) for non-standard and non-off-the-shelf printed circuit (PC) boards.

G. Page Format

1. Left, right, and top margins: 1 inch

2. Bottom margin: 0.75 inch

3. Revision date: At bottom center of each page with month and year (e.g. REV DEC/94)

4. New sections and chapters shall begin on a right-hand facing page. If there is a blank left-hand page at the end of a chapter or section, include on that page. “THIS PAGE INTENTIONALLY LEFT BLANK” (Arial, 11 pt., black font) in capital letters.

5. Paragraph Format

   a. Font and font color: Arial, black

   b. Titles and first level headers: 12 pt., bold, in capital letters

   c. Second level headers and subheadings: 11 pt., bold, in sentence case letters

   d. Body text: 11 pt., left justified, single space, and 12 pt. spacing between paragraphs

   e. Bullets

      1) First level bullet: Solid style (-), indented once

      2) Next level bullet: Dash style (–), indented twice

      3) Indents: 1/2-inch

   f. Footer content shall include on each line and in the following order:

      1) Book number

      2) Volume number

      3) Page number

6. Footer content shall align to the bottom outer corner of page when printed.

H. Technical Illustrations:

1. Draw illustrations, including “exploded” views and illustrated part breakdowns. Use illustrations to facilitate descriptions of assemblies and the relationships of components, subsystems, and systems. Illustrations shall conform to ASME Y14.5 and IEE 315.

2. Technical illustrations shall comply with the following requirements:

   a. Illustrations shall include details necessary for the installation, maintenance, and repair of equipment installed. Details shall be readable.

b. Each illustration shall be designated as a “figure”. The word “Figure,” accompanying numerical designation and caption shall be the same size, style, and type as the written text. Its physical location shall be the same on each page.

c. Figure numbers and descriptions of figures shall be readable in the horizontal position as you read the page from left to right.

d. Figures containing graphics, illustrations, diagrams, and similar drawings, shall be readable and appear at the end of the applicable section or procedure.

e. Whenever callout numbers are used in an illustration, they shall be circled and readable.

f. Graphic symbols used for electrical, and electronics shall conform to IEEE 315.

g. Graphic symbols used for logic diagrams shall conform to IEEE 315.

h. Drawing file and drafting requirements including line convention and lettering shall conform to the BFS Appendix Contract Drawing CADD Requirements.

2.05 ASSET REGISTER

A. Submit in an electronic format an asset register of the assets and assets’ attributes provided in the Contract. Include new, modified, and decommissioned assets resulting from the Contract. Complete the asset register using the template furnished by the Engineer.

PART 3 – EXECUTION

3.01 MANUAL PREPARATION

A. Obtain from Engineer a book number assigned by the District’s Technical Publications unit for each manual. Label manual using the assigned book number.

B. Obtain from Engineer artwork templates. Use the artwork templates for the front cover, spine, internal cover page, and configuration control record.

C. Examples of manuals may be requested from Engineer for Contractor reference.

D. Obtain instructions and manuals from Suppliers of District-furnished equipment.

E. Prepare and submit outline, draft manual, and pre-final manuals for review. Non compliant manuals will be marked and returned to Contractor for resubmittal. Revise and submit within 42 Days.

F. Submit final manuals.

3.02 MANUAL REVISION CONTROL

A. Provide revisions to manuals and update the Configuration Control Record form in the front of each manual from acceptance of final manual through the warranty period. Form shall include columns for the chapter, page number, revision date, and revision description.

B. Revisions shall be prepared prior to the arrival of altered components, and as soon as possible after procedures are changed or errors are found.

1. Provide revisions to approved manuals on a quarterly basis during the first 12 months after the final manuals are delivered. Afterwards, revisions shall be provided on a semi-annual basis for the duration of the warranty period.

2. Issue revisions related to major alterations of principal subsystems or assemblies prior to the arrival of components.

C. Revisions shall be made for design changes, retrofits, and errors as required, and based upon changes generated during testing. These revisions shall be listed on a List of Effective Pages to be issued with each review submittal and revision of the manuals until expiration of the Contract.

END OF SECTION 01 78 23

SECTION 01 78 39

PROJECT RECORD DOCUMENTS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Maintenance of Record Documents.

B. Drawings.

C. Specifications.

D. Submission of documents.

1.02 MEASUREMENT AND PAYMENT

A. Separate measurement or payment will not be made for work required under this Section. All costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work.

1.03 MAINTENANCE OF RECORD DOCUMENTS

A. Maintain at the Jobsite one copy of the following documents for record purposes:

1. Conformed Contract Documents. One set of full size 22 by 34 inch prints shall be maintained for recording "as-built" revisions and special features.

2. Change Orders.

3. Approved Submittals.

4. Clarifications or Explanatory Details and Specifications or Request For Information (RFI).

5. Inspection Reports.

6. Laboratory Test Records.

7. Field Test Reports and Records.

8. Factory Test Reports and Records.

B. Maintain for record purposes at a location approved by the Engineer, electronic files for those shop drawings and other documents which are required to be submitted electronically. Ensure that backups of electronic files are made on a regular basis and stored at a remote location.

C. Store documents used for record purposes in the Contractor's field office or other approved location, apart from documents used for construction. Do not use record documents for construction or fabrication purposes.

D. Provide files and racks for storage of documents.

E. File documents in accordance with the filing format of the Contract Specifications, by Section number and title.

F. Maintain documents in clean, dry, legible condition.

G. Label each document "Project Record".

H. Make documents available at all times for inspection by the Engineer. Make copies of electronic documents available upon Engineer's request.

1.04 DRAWINGS

A. Record ("As-Built") Drawings:

1. Maintain record ("as-built") drawings of all work and subcontracts, continuously as the job progresses. A separate set of prints, for this purpose only, shall be kept at the Contractor's field office at all times.

2. These drawings shall be kept up-to-date and are required to be so certified by the Engineer at the time invoices are submitted for progress payments. The Engineer may withhold progress payments if record drawings are not kept current.

3. The District will furnish the Contractor a complete set of full-size copies of the Contract Drawings for the purpose of making prints for record ("as-built") drawings.

4. Deviations from the drawings, utilities and services, mechanical and electrical lines, details, and other work shall be incorporated on the record ("as-built") prints in red ink, or in red pencil if sharp, neat, and clearly legible.

5. During the course of construction, identify actual locations to scale in red ink on the Contract Drawings for runs of mechanical and electrical work, including utilities and services, installed in walls, or otherwise concealed. Deviations from the Drawings shall be shown in detail. Locate main runs, whether wiring, piping, conduit, ductwork, or drain lines by dimension and elevation. Shop Drawings may be used to reflect record ("as-built") conditions, in which case the appropriate Contract Document shall be marked to refer to such Shop Drawings as part of the record ("as-built") configuration.

6. No work shall be permanently concealed until the required information has been recorded.

7. Where the Contract Drawings are not of sufficient size, scale, or detail, the Contractor shall furnish its own drawings for incorporation of details and dimensions.

8. The final submittal of record ("as-built") drawings shall be stamped "Project Record ", signed and dated in blue ink by the Contractor, and shall be delivered to the Engineer prior to the final inspection as specified in Section 01 77 00, Closeout Procedures.

B. Change Orders:

1. Changes to the Contract Drawings as the result of Change Orders shall be incorporated on the prints, and these changes shall be identified by Change Order number and effective date.

2. When revised Contract Drawings are issued as the basis of, or along with, Change Orders, these revised drawings shall be incorporated into the record ("as-built") set with appropriate annotation. Drawings deleted by Change Order will not be part of the record ("as-built") set. The District will furnish the Contractor with reproductions of such revised District-furnished Contract Drawings.

C. Submittals:

1. One complete set of approved Submittals, including shop drawings, product data, manufacturers' printed catalog cuts and data, shall be collected and maintained for record purposes.

2. Pages of catalog cuts shall be clear, legible, and permanent. The drawings shall be on vellum or bond paper. Blueprints will not be acceptable. These drawings and catalog cuts shall become the property of the District.

3. Submittals shall be filed and maintained separate from Contract Drawings and Shop Drawings. Documents shall be filed in nine inch by 12 inch file folders to the greatest extent possible and shall be indexed as herein before specified.

4. Submittals shall be delivered in new paperboard boxes manufactured for the storage of file folders. Boxes shall have covers and cutout handles, and shall be accurately identified as to the contents. Include a packing list of all boxes and their contents.

D. Electronic Documents: Record (“as-built”) information, as applicable, shall be recorded on an electronic copy of those documents which are required to be submitted electronically.

1. For those drawings which are required to be submitted electronically, submit one complete set of full size (22 by 34 inch, unless otherwise required) hard copy originals plotted on 20 pound bond paper, zero solvent. The image shall be pressure-fused using a laser or LED plotter. Inkjet plotter is also acceptable. Sepia, blue or brown lines are not acceptable.

2. Record documents for each submittal which was required to be prepared and submitted electronically shall include two CD-ROMs of the electronic version. Electronic files shall include a matrix or document showing how the files are set up and how to access them. Include no extraneous files. Folder arrangement must be clear and understandable and subfolders are to be used only when necessary.

3. When specified by the Contract, Record Drawing shall be prepared and submitted electronically. Such drawings shall be created using AutoCAD in accordance with the District's Contract Drawing CADD Requirements (part of the BART Facilities Standards, Appendices, District Technical Manuals).

1.05 SPECIFICATIONS

A. Contract Specifications:

1. The specifications for record purposes shall be filed in one or more large-ring, three-ring binder or binders.

2. Information, changes, and notes shall be recorded in the specifications in blank areas, such as page margins or the backs of opposite pages, or on separate sheets inserted in the binder. All such information, changes, and notes shall be legibly recorded with red pen or red printing as appropriate.

3. In applicable specification sections, record the manufacturer, trade name, catalog number, and supplier of each product and item of equipment actually furnished and installed, including manufacturer and supplier's address and telephone number.

4. The record specifications shall be complete and shall include all applicable Contract Documents other than drawings.

B. Change Orders:

1. Change Orders shall be incorporated into the front of the record specifications in reverse chronological order. Use appropriate page dividers to identify Change Orders and to separate Change Orders from the Specifications.

2. In addition, changes to the Specifications effected by Change Order shall be legibly annotated on the affected page or pages of the Specifications or adjacent thereto.

1.06 SUBMISSION OF DOCUMENTS

A. At completion of the Work, and before requesting final inspection, deliver Jobsite record documents to the Engineer.

B. For record ("as-built") drawings, submit the blackline print (full size) with revisions incorporated on the prints in red ink. For those documents which are required to be

maintained electronically, submit full size plot of drawings, hard copies of 8 1/2 by 11 inch documents, and electronic files on CD-ROM.

C. Software:

1. Submit all documentation, licenses, and electronic media associated with the purchase of commercially available software furnished to the District under this Contract. The documentation and media shall be submitted in appropriate storage containers or in the original media packaging.

2. Where development of User's Guides is specified, User's Guides shall be submitted.

3. Unless otherwise specified, documentation shall be prepared in accordance with recognized industry standards for such documentation as approved by the Engineer.

D. Record documents, separate from Contract Drawings and Shop Drawings, shall be delivered neatly and efficiently filed and packaged in appropriate file storage cabinets or boxes, 12 inches by 16 inches in size.

E. Submission of record documents shall be accompanied with a transmittal letter, in triplicate, containing the following information:

1. Date of submission.

2. Project title and number.

3. Contractor's name and address.

4. Title and number of each record document. (Shop Drawings may be grouped in basic categories or divisions of work and by box identification.)

5. Certification that each document as submitted is complete and accurate.

6. Signature of Contractor, or its authorized representative.

PART 2 – PRODUCTS

Not Used

PART 3 – EXECUTION

Not Used

END OF SECTION 01 78 39

SECTION 01 78 44

SPARE PARTS AND MAINTENANCE MATERIALS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Spare parts.

B. Maintenance materials.

C. Keys, special tools, and test equipment.

1.02 RELATED SECTIONS

A. Coordinate the work of this Section with the work specified in Section 01 78 23, Operation and Maintenance Data, for lists of spare parts.

B. Keys for finish hardware are specified in Contract Specifications Section 08 71 00, Door Hardware.

1.03 MEASUREMENT AND PAYMENT

A. Separate measurement or payment will not be made for work required under this Section. All costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work.

1.04 REFERENCES

A. Automotive Industry Action Group (AIAG):

1. Auto Industry Code 39

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, for submittal requirements and procedures.

B. Spare Parts Lists:

1. Prepare and submit a complete list of recommended spare parts for all equipment, appliances, and systems as specified in the various individual Sections of these Specifications, as applicable, and in the Contract Specifications.

2. The Spare Parts List shall include all spare parts as required to provide for the maintenance and repairs of all Contractor-furnished equipment and appliances for a period of two years.

3. The Spare Parts List shall be organized in accordance with the Contract Specifications, by Section number and title.

    a. The Spare Parts List shall include the part's generic name or description, its trade name, Contractor's part number, manufacturer's name, manufacturer's part number, retail price, quantity, and correlation with the pertinent Contract Specifications, Contract Drawings, and Maintenance Manuals specified in Section 01 78 23, Operation and Maintenance Data.

    b. Spare parts shall be grouped by equipment category. Replacement parts common to more than one category shall be cross-referenced and indexed. Such common parts shall have only one part number.

C. Maintenance Materials List:

1. Prepare and submit a complete list of maintenance materials as specified in the various individual Sections of these Specifications, and in the Contract Specifications.

2. The Maintenance Materials List shall be organized in accordance with the Contract Specifications, by Section number and title. Include the quantities to be furnished.

3. Where maintenance materials are specified as a percentage of the materials installed, such percentages shall be translated to actual quantities of materials in the Maintenance Materials List.

D. Keys, Special Tools, and Test Equipment List:

1. Prepare and submit a complete list of the keys, special tools, and test equipment as specified in the various individual Sections of these Specifications, and in the Contract Specifications.

2. The Keys, Special Tools, and Test Equipment List shall be organized in accordance with the Contract Specifications, by Section number and title.

1.06 SPARE PARTS

A. Requirements:

1. Provide specific spare parts as specified in the individual Sections of the Contract Specifications.

2. Spare parts shall be identical to the parts installed in the Work.

B. Quantities: Provide quantities based on reliability requirements, replacement lead time, the Contractor's recommendations, and the following requirements:

1. Wear: Provide spare parts for components which may be expected to require regular replacement under normal maintenance schedules, such as mechanical parts subject to continuous operation.

2. Consumability: Provide spare parts for components with a life-expectancy of less than 5 years.

3. One-Time Limited Service: Provide spare parts that normally require replacement after performing their function one time, such as fuses.

4. Long Lead Time: Provide spare parts for components that are not readily available from distributors, such as for custom-fabricated components.

5. Exchange Assemblies: Provide assemblies which will be exchanged with malfunctioning units for installed equipment, and which must be inventoried as complete assemblies.

1.07 MAINTENANCE MATERIALS

A. Requirements:

1. Provide maintenance materials as specified in the individual Sections of the Contract Specifications.

2. Maintenance materials shall be identical to the materials installed in the Work.

B. Quantities: Provide quantities of materials as specified in the individual Sections of the Contract Specifications.

1.08 KEYS, SPECIAL TOOLS, AND TEST EQUIPMENT

A. Requirements: Provide sufficient keys, special tools and wrenches, and special test equipment and gages as required to access, start, maintain, and repair all the installed equipment, appliances, systems, and assemblies as specified in the individual Sections of the Contract Specifications.

B. Quantities: Provide quantities of keys, special tools, and test equipment as specified in the individual Sections of the Contract Specifications.

1.09 BAR CODE

A. All spare parts with the manufacturer’s or supplier’s serial number or other identification shall also be identified with bar codes, coded in accordance with the District’s Bar Coding System (AIAG Auto Industry Code 39) or equivalent. The System details will be provided by the Engineer.

1.10 PACKAGING

A. Comply with applicable requirements of Section 01 60 00, Product Requirements. All spare parts, maintenance materials, keys, special tools, and test equipment shall be securely packaged in boxes, with the boxes clearly labeled as to the contents. Such labeling shall include: location and description of the equipment and the item, complete listing of all items in the box, and the quantity of each item included in the box.

1.11 DELIVERY

A. Deliver spare parts, maintenance materials, keys, special tools, and test equipment to the warehouse location or locations specified in the Contract Specifications. Provide unloading service at the designated storage location for all delivered products.

B. Prepare formal receipts for all such delivered products, and have them signed by the authorized District Representative at the location. A copy of all such receipts shall be submitted to the Engineer for information and record.

1.12 STORAGE

A. Spare parts, maintenance materials, keys, special tools, and test equipment may be stored temporarily at the site of the work in suitable storage facilities until time to deliver these products to the locations designated in the Contract Specifications. Any such storage shall comply with the requirements specified in Section 01 60 00, Product Requirements.

PART 2 – PRODUCTS

Not Used

PART 3 – EXECUTION

Not Used

END OF SECTION 01 78 44

SECTION 01 79 00

DEMONSTRATION AND TRAINING

Attachment 1: Training Course by Audience to be completed by District personnel prior to contract bid.

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Specifications for training deliverables and the training of District personnel in the installation, management, operation, and maintenance of furnished equipment and systems.

B. Where training requirements are specified under another Section in these Specifications, coordinate requirements with the requirements specified herein to provide a complete and comprehensive training program.

1.02 RELATED SECTIONS

A. Section 01 33 00 Submittal Procedures

B. Section 01 43 00 Quality Assurance

C. Section 01 78 23 Operation and Maintenance Data

1.03 MEASUREMENT AND PAYMENT

A. Consider final payment for all training material deliverables for each specification section to be a separate schedule of values line item in the bid schedule of the Contract and not be a part of a related item of work in the price schedule or incidental to the work.

See the following language in Specification Section 01 20 00, Price and Payment Procedures, Article 1.02 para. A.1:

If the Contractor requests progress payments for lump-sum items or amounts in the bid schedule, such progress payments will be made in accordance with a well-balanced, detailed program of payment – apportioning, prepared by the contractor and submitted to the Engineer for approval. Such payment-apportioning may require modifications during the contract, as determined by the Engineer.

1.04 DEFINITIONS

A. Audience: Group of individuals to be trained, typically from the same or similar job classifications.

B. Class: A group of students attending the same course at the same time and place.

C. Classroom training: Training occurs in a classroom setting. May include various delivery methods.

D. Computer Based Training: Training occurs in a classroom or office setting. Content is delivered through a computer module. The delivery may or may not require instructor technical support or moderation.

E. Course: Related content organized in modules and lessons. Content is directed towards achieving an expected measurable outcome.

F. Course Evaluation: A written review by the students, providing feedback on the course content and quality of presentation.

G. Curriculum: A series of courses intended for the same group of participants (for example, electricians.)

H. Delivery Method: How the content will be delivered. Typical methods include lecture, demonstration, computer-based, hands-on practice.

I. Demonstration Training: A class delivered to determine if the course meets the expected outcomes defined by this specification and the training plan.

J. Employee Development Specialist (EDS): Trainer.

K. Familiarization training: Instructor describes, points out or demonstrates on the equipment. May occur either in the field or a simulated classroom environment.

L. Field Instruction/Training: Delivery of content occurs at the location where the equipment or system being trained is installed or maintained.

M. Go-Live: System and/or equipment is released for use by District staff or start of revenue service, whichever date is later.

N. Hands-On Practice: Each class participant practices installation, maintenance, operation, or configuration with the equipment and tools in class. Practice mirrors work participants shall perform on the job.

O. Instructor Guide: A document that is a written record of all the facts and details required for an instructor to teach a course so that training objectives are met, students receive consistent information and experience similar activities regardless of the instructor delivering classes.

P. Lecture: Instructor speaking to students, asking questions, presenting slides or using other reference materials.

Q. Lesson: A component of learning that contributes toward the outcome of a module.

R. Module: A self-contained segment of learning consisting of a series of lessons that covers key topics of a course and has an independent outcome.

S. Prerequisite: Knowledge or skill required prior to attending a course to be successful in the course.

T. Staged Training: Delivery of classes to the audience.

U. Student Guide: A document provided to follow course delivery including all documents a student will reference or need to participate in class. Allows students to follow the lessons and organize class notes.

V. Training Program Plan: An approach for training specific knowledge and skill with a defined outcome.

W. Train the Trainer (TTT): Delivery of a class to participants who are expected to be able to redeliver the same content with the same results. Delivery includes additional time spent with the participants to explain how to set up the classroom, deliver the class using the training materials, and use any special tools or equipment required to deliver the course.

1.05 TRAINING PROGRAM DESCRIPTION

A. The training program shall:

1. Be approved by the District. At least one approver shall be from the applicable training department.

2. Train District's training, maintenance, engineering, and operations personnel in details of the furnished systems and equipment.

3. Enable District personnel to install, operate, service, configure, maintain, and interact with the hardware, software, and firmware, such that the systems and equipment will perform in accordance with the requirements in the individual Sections of these Specifications.

4. Enable engineering personnel to install, configure, modify, and perform application software development, application software updates, hardware adds, moves, changes to systems and sub-systems on a continuing basis.

5. Be designed to be replicated without impact to project testing or revenue service when delivered after Go-Live.

6. Identify delivery methods and training equipment required for content delivery including classroom, hands-on, and field instruction and training aids to conduct the training program.

7. Be District specific including how the system and equipment integrate with other equipment and systems within the District.

8. Consist of a logically-related sequence of separate Courses covering the content required herein.

9. Incorporate, as applicable, the requirements of regulatory agencies and instruments, such as the California Public Utilities Commission (CPUC), American With Disabilities Act (ADA), Environmental Protection Agency (EPA), California Code of Regulations: Title 8, California Occupational Safety and Health

Administration (CAL/OSHA), California Building Code (CBC), and the California Department of Motor Vehicles.

B. Provide access to technical personnel as needed to consult with District's training representatives to support review and development of training programs.

1.06 SUBMITTALS

A. Refer to Section 01 33 00, Submittal Procedures, for submittal requirements and procedures.

B. Attend a one-day training submittal workshop with a District training representative prior to demonstration and training submittals. The purpose of the workshop is to make the submittal process more efficient by clarifying expectations of this section, reviewing attachment information, discussing audience expectations, and answering questions.

C. At least 7 Days prior to submittal of Training Program Plan, provide a familiarization walkthrough to include a tour of the facility and equipment (or representative example), basic explanation of planned function, operation, location and integration with legacy equipment, for a minimum of six (6) District training submittal approvers for each course planned. Focus of walkthrough is to understand work performed, differences from legacy systems and equipment, and required Audience for each course.

D. Obtain verification in writing from the Engineer that training submittal prerequisites (documents and equipment) as defined in Table 1 of this Section have been met.

E. Submittals of written documents shall be in a native electronic format that is searchable with changes visible (e.g. MS Word Track Changes).

F. Submit the following for each course:

1. Training Submittal Schedule
2. Training Program Plan
3. Instructor resumes
4. Instructor guides and attachments
5. Student guides
6. Training aids and supporting documentation
7. Training demonstrations
8. Staged training schedule
9. Training reports

10. Final deliverables

G. A submittal will not be approved prior to receipt of each training program prerequisite per Table 1 below.

This table identifies the prerequisites required before a submittal can be approved. The Submittal Schedule shall reflect these dependencies.

Table 1: Training Submittal Prerequisite Table

Submittal	**Prerequisite**
Training Submittal Schedule	
Training Program Plan	• Training Submittal Schedule • District approver familiarization walkthrough
• Instructor guides & student guides • Training aids supporting documentation • Training locations identified	• Approved Training Program Plan • Approved prefinal O&M manual
Training aids installation at training location	Room locations approved and secured
Instructor resumes	Approved Training Program Plan
Training demonstration	• Training aids installed at training location • Verification equipment/system is working as designed • Approved instructor guide • Approved student guide • Approved instructor resume • Approved prefinal O&M manual
Staged training class schedule	Approved training demonstration & updated materials
Training delivery starts	• Lead time for scheduling met • Mitigation if required (Go-Live more than 5 months before training start) • Approved staged training class schedule
Final deliverables	Last class delivered
Updates to materials	Updates to system or equipment if needed

1.07 VIDEO AND AUDIO RECORDINGS

A. Prerecorded lectures or lessons shall not substitute for a classroom instructor.

B. Record and provide electronic copies of the presentation of the training courses.

1.08 SUPPLEMENTAL TRAINING

A. Conduct supplemental training courses if the form, fit, or function of the system or equipment is modified or reconfigured after start of the staged training.

B. During warranty period, provide arrangements for District staff to accompany warranty support personnel during service calls.

1.09 REVISIONS

A. Revise training program deliverables and training aids to incorporate design changes, retrofits, changes generated during testing, and to correct errors and omissions.

B. Updates and revisions to the instructor guides, student guides, and attachments shall be incorporated no less than quarterly for the duration of the Contract and warranty.

1.10 QUALITY ASSURANCE

A. General:

1. Training program deliverables shall be developed, fabricated, assembled, submitted, demonstrated, evaluated, and reworked as required, in accordance with the District's quality assurance standard.

2. Meet quality assurance standards specified in Section 01 43 00, Quality Assurance.

B. Evaluation and Approval: Training program will be examined, checked, inspected, and evaluated by the District to achieve the following objectives:

1. Verify that the workmanship and content comply with requirements herein.

2. Identify and document nonconformances in materials, workmanship, and technical content.

3. Recommend rework actions to correct defects.

4. Recommend process improvements to prevent repetition of those nonconformances.

C. Examinations, checks, inspections, and evaluations performed by District to verify compliance shall not relieve the Contractor of responsibility to comply with the requirements herein.

D. Contractor may request authorization to depart from a requirement herein or may request that District accept a training program deliverable identified as nonconforming by submitting a request for deviation or waiver.

PART 2 – PRODUCTS

2.01 TRAINING SUBMITTAL SCHEDULE

A. Prepare a submittal schedule (reference Table 1: Training Submittal Prerequisite) for training activities including document delivery dates; review and acceptance periods; training class preparation time; lead times for delivery scheduling; and class delivery. Schedule to include critical path milestones from the Contract Schedule as defined in 01 32 16, Construction Progress Schedules. Schedule to be approved by the District.

1. Obtain approval of class schedule four (4) weeks prior to delivery of staged training.

2. Start staged training delivery no sooner than five months before go-live unless a mitigation plan for the gap between training completion and go-live is defined and accepted.

2.02 TRAINING PROGRAM PLAN

A. The Training Program Plan shall include a list of courses and the following details for each course:

1. A course description and objectives

    a. Course description shall be a summary of what is included in the course and shall include

        1) Modules covered in the course.

        2) List of new equipment including model numbers.

        3) List of equipment or systems that are integrated with new equipment or systems to be trained.

    b. Objectives shall be precisely worded statements of the end-of-course performance expected of the students. Course objectives shall include:

        1) The knowledge, skills, and abilities students will acquire by the end of the course.

        2) The methods of evaluating achievement of the objective (e.g. written exam, performance evaluation, oral quiz).

        3) The conditions under which the evaluation will occur (e.g. open book, on a simulator).

        4) The measurable level of performance required.

2. Planned target population for each course based on feedback from walkthrough from Article 1.6.C herein feedback and Attachment 1: Training Courses by Audience.

3. An outline of the major modules covered in each course broken down into increments of either:

   a. 2 hours or less, or

   b. One quarter of the total time to teach the course

   whichever is less. If a module will take more than what is indicated above to teach, it shall be broken into additional modules to meet this requirement.

   Each module shall include:

   a. Short description of content covered.

   b. Approximate time allocation.

   c. Where it will be delivered; field or classroom.

   d. Delivery method (lecture, demonstration, hands-on practice)

   e. List of training equipment, tools, training aids required.

   Total course length shall be no less than the length defined in Attachment 1: Training Courses by Audience.

4. A list of equipment, tools, and training aids being provided to deliver the training.

5. Description of method of evaluating student knowledge and skill, for example written or performance exercises.

   a. Provide grading system to identify students for whom further training is required and include a remediation plan for students who do not meet mastery level. Grading system shall be approved by the District.

6. A list of prerequisites for each course:

   a. Include other courses from within the plan that need to be completed.

   b. Include knowledge and skills that need to be acquired prior to start of this program plan and strategy to meet these requirements.

   c. Assume that the personnel to be trained have only the basic skills pertinent to their craft, as outlined in the District's job descriptions.

   d. Assume that District personnel to be trained have no knowledge of features of the system or equipment to be taught.

2.03 INSTRUCTOR RESUMES

A. Instructor qualifications, listed below, shall be documented in a resume and other supporting documents as required to demonstrate compliance with these requirements. In the case of a knowledge or experience gap, document how and when the gap will be filled.

   1. Fluency in English and ability to be heard in required training situation.

2. Experience as a classroom instructor.

3. Possesses relevant licenses, equipment or factory certifications for subject taught.

4. Relevant technical and practical experience with the District-contracted system and equipment installation at the level (installation/operations/maintenance /configuration) required to teach the course. The instructor for configuration courses shall have direct engineering experience and expertise for the specific system(s) trained.

5. A thorough knowledge of the instructor guides, training manuals, references, procedures, tools, test equipment, and other training aids required to present the training courses.

6. Obtain District approval of instructor resumes at least 30 Days prior to the scheduling of demonstration training or if any change in instructor becomes necessary during the Contract.

2.04 TRAINING COURSE CONTENT REQUIREMENTS

A. Courses shall provide students practice using source and reference documents.

B. Courses shall provide students with hands-on practice of key, unique, or new procedures and troubleshooting.

C. Each course shall include a quick reference document for critical or emergency situations if applicable.

D. Each course shall be District-specific and applicable to the BART environment and job function.

E. Each course shall include how the system or equipment integrates into other BART equipment and systems.

F. Each course shall include pertinent safety precautions for the system or equipment being trained, including LOTO procedures and other applicable Control of Hazardous Energy (COHE) requirements.

G. Each course shall include a test or performance evaluation.

1. Written and/or performance-based evaluations shall be used to determine whether each student has learned the objectives for the course.

2. Tests and performance evaluations shall validate participant ability to install, operate, maintain, and configure equipment and systems to the requirements identified herein. Testing and evaluation items must directly link to the content of the class and cover the range and complexity of the course. Questions that evaluate course prerequisites are not acceptable.

3. Tests and evaluations shall be designed to be completed independently by each student and have a grade to indicate mastery of the course content.

4. Grades shall be kept strictly confidential and shall be submitted only to the District training department.

5. The instructor will grade tests and go over the answers of quizzes, tests, and performance evaluations given during class delivery after the test or quiz is completed.

H. The training program shall be conducted for the equipment, systems and audiences listed in Attachment 1: Training Courses by Audience.

1. Classes noted as TTT in Attachment 1: Training Courses by Audience will be delivered by the Contractor to District trainers and include items indicated in 3.2.A.11 and 2.5.I herein.

2. Classes noted as Contractor Delivered shall be delivered to District personnel identified in Attachment 1: Training Courses by Audience.

I. In cases where the training scope is not defined in Attachment 1: Training Courses by Audience, propose a scope for approval by the District, in consultation with the training department.

J. The training program shall not be limited to the equipment and systems listed in Attachment 1: Training Courses by Audience, if the District determines that additional courses are required to achieve the objectives of the training program.

K. When an operation and maintenance (O&M) manual is referenced herein, it shall be understood to mean the O&M manual prepared for the specific system or equipment, in accordance with Standard Specifications Section 01 78 23, Operation and Maintenance Data.

L. Course content shall meet the requirements for the specified course type. There are 5 course types: Installation, System and Equipment Operation, System Configuration, Primary Maintenance, Secondary Maintenance. The type of course required for each subject is dependent upon the primary audience for the course. Course types can be combined if appropriate to the audience.

1. Installation training courses:

a. Enable District personnel to install, configure, test, troubleshoot, and accept systems and equipment.

b. Provide hands-on practice installing, configuring, testing and placing equipment or services into a production environment.

c. Review written procedures for installation.

2. System and Equipment Operation training courses:

    a. Enable District personnel to operate the facility, system, and equipment unassisted including interfaces to other equipment.

    b. Provide classroom and hands-on practice in operation of the facility, system, and equipment including operation level troubleshooting.

    c. Cover written procedures from the O&M manual for the following:

        1) Operating the facility, system, and equipment.

        2) Operator-level fault diagnosis and corrective action.

3. System Configuration training courses:

    a. Enable District personnel to configure and program the system and equipment.

    b. Provide classroom and hands-on practice in the use of the software and firmware development environments.

    c. Enable District personnel to install software revisions and upgrades.

    d. Provide training in the use of the software and firmware development environment to enable the District personnel, including Engineering staff, to perform application software development and modifications; and hardware adds, moves, and changes for the equipment and systems.

    e. Provide hands-on practice to fully demonstrate each procedure to configure, modify, and perform application software development, application software development, updates, hardware adds, moves, and changes to all equipment room systems, wayside systems, and sub-systems.

    f. Provide training on each procedure to configure, modify, and perform application software development, application software updates, hardware adds, moves, and changes to all equipment room systems, wayside systems, and sub-systems.

    g. Include warranty timeframes and limitations.

4. Primary Maintenance training courses:

    a. Provide detailed theory of operation including power distribution, data paths, and signal conditions for inputs and outputs of electromechanical modules and sub modules.

    b. Provide practice with written procedures from the O&M manual for facility, system and equipment operation, preventive maintenance, and corrective maintenance.

    c. Provide students with hands-on, step-by-step instruction and practice in the disassembly and assembly of mechanical, electrical, electromechanical, and electronic modules and sub modules to the lowest level field replaceable units (LLFRUs).

d. Train District personnel to utilize facility, system, and equipment documentation to perform preventive and corrective maintenance.

e. Provide students with hands-on instruction and practice in preventive maintenance, including procedures for cleaning, lubricating, and adjusting; and for evaluating the wear of modules and sub modules.

f. Enable District maintenance personnel to practice corrective maintenance to diagnose, isolate, and repair faults to the LLFRU using commercially available and special test equipment supplied under the Contract.

g. Include warranty timeframes and limitations.

5. Secondary Maintenance training courses:

a. Provide detailed theory of operation including power distribution, data paths, and signal conditions for all inputs and outputs of all modules, sub modules, and circuit boards to component level.

b. Provide practice with written procedures from the O&M manual, for system and equipment operation, preventive maintenance, and corrective maintenance to component level.

c. Provide students hands-on, step-by-step instruction and practice in the disassembly and assembly of mechanical, electrical, electromechanical, and electronic modules and sub modules to component level.

d. Train District personnel to utilize system and equipment documentation to perform preventive and corrective maintenance to the component level.

e. Provide students hands-on instruction and practice in preventive maintenance, including procedures for cleaning, lubricating, and adjusting, and for evaluating the wear of modules and sub-modules to the component level.

f. Enable District maintenance personnel to practice corrective maintenance to diagnose, isolate, and repair faults to component level, using commercially available and special test equipment supplied under the Contract.

g. Enable District maintenance personnel to operate and maintain (diagnose, isolate, and repair faults to the component level), special test equipment, maintenance test bench, and fixtures supplied under the Contract.

2.05 TRAINING AIDS AND SUPPORTING DOCUMENTATION

A. Provide training aids required to train course participants. Training aids include: training devices, special tools, fixtures, racks, models, mockups, simulators, application software, development tools, software development environment, development computer(s), compilers, prom programmers, and other equipment for the course.

B. Training aids used in the course shall be connected and configured to faithfully simulate the District environment.

C. Training aids shall be integrated/interfaced into corresponding existing training and wayside training equipment where needed to faithfully simulate the BART revenue environment.

D. Training aids shall be installed with the appropriate essential and non-essential power and mounted for earthquake safety.

E. Training aids will be designed to allow replication of training without impact to project testing or revenue service when delivered after go-live.

F. Contractor will verify training aids are fully functional before delivery of any training course.

G. Provide District with revisions to the training aids to faithfully simulate the District environment, during the performance of the Work, including applicable warranty terms.

H. Training aids shall be of durable construction and shall become the property of District on completion of staged training.

I. Source code used in the development of computer-based training materials or simulations shall be provided and become the property of District.

J. A TTT course is required on the use of training aids and other equipment required to train course participants to enable personnel to configure, maintain and use supporting documentation for training aids provided.

K. Provide supporting documentation including O&M manuals, Book of Plans, and complete specification documents for training aids and other equipment required to train the course.

L. Provide a complete set of all software, development tools, compilers for training aids to enable repair and rebuild of training aids.

M. Spare parts for training aids shall be provided and covered under the same spare parts requirements as the corresponding revenue service installation.

2.06 INSTRUCTOR GUIDE

A. Prepare instructor guides and attachments for the approval of the District. Current District template to facilitate compliance with this Section available upon request.

1. Instructor guide shall be detailed enough to determine what the instructors and students are doing during the course.

B. Provide one instructor guide for each training course. Each instructor guide shall be arranged as specified herein.

C. Content, including attachments, shall be clear and readable in the format intended for class. (e.g., slides will be clear on the computer screen as well as when projected for class).

D. Guides shall contain a Table of Contents and each page will have a footer that includes the document title and page number.

E. The title shall be short and descriptive and contain the name of the training course and, if applicable, the target population (e.g. AFC Equipment Operation for Station Agents).

F. Time to Teach: An estimate of the time to teach the lessons in a training course. The actual time to teach may vary with student loading and knowledge level. Time to teach estimate is to be based on class size in Attachment 1: Training Courses by Audience. This includes delivery, breaks, and travel time within the training session required for class.

G. Course timeline, to include in order:

1. Lesson titles

2. Time to teach each lesson

3. Type of instruction employed in delivering each lesson, such as classroom, hands-on, or field.

H. Objectives: Each instructor guide shall have one or more performance-based objectives. See Article 2.02.A.1.b herein for requirements for writing objectives.

I. Reference Documents List: The O&M manual shall be the primary reference document for the instructor guide. Sources of the material presented in the instructor guide shall be listed. Reference documents may include test equipment manuals, original equipment manufacturer manuals, software manuals, and documents developed by the Contractor for this Contract.

J. Materials and Equipment: Material and equipment used in the presentation of the training course shall be listed in the instructor guide, and may include the following:

1. Student guide titles

2. Training tools such as dry erase boards, markers, erasers, easels, projectors, and monitors.

3. Training aids and equipment such as hand tools, notebook computers, test equipment, training racks, simulators, fixtures, and parts for disassembly.

4. Special facility requirements, such as compressed air, network access, or unusual power requirements.

K. All materials and equipment used in the presentation of training are deliverables and shall become the property of District.

L. Introduction:

1. Name and background of the instructor.

2. An overview of the subjects covered in the training course.

3. The objectives of the training course.

4. The outline of the training course.

5. The schedule of course activities, breaks, and class hours.

6. Safety precautions related to the training environment.

7. Classroom rules and procedures.

8. Facility information, such as location of restrooms, lunchrooms, parking, and emergency evacuation routes.

M. Presentation:

1. Serves as a written record of the specific facts and information in the training course.

2. Consists of a series of modules and lessons covering the key topics of the course.

3. Clearly describes the delivery method (lecture, demonstration, practice, video, etc.) of each lesson and time to teach.

4. Provides clear directions for the instructor for set up of student exercises and activities.

5. Is detailed enough for another instructor with knowledge and experience in the subject to teach the training course.

6. Ensures that the information presented during the training is consistent each time the course is taught.

7. Ensures achievement of the objectives of the training course.

N. Summary: This shall be a comprehensive review of the lesson objectives, summarizing key elements of the training for the entire course.

2.07 INSTRUCTOR GUIDE ATTACHMENTS

A. Provide training materials required for presentation of the course with the instructor guide. The following attachments, as used in the course, shall be supplied with each instructor guide at Submittal:

1. Slides, pictures, videos, tables, charts, diagrams, self-paced instruction, computer-based training, and multimedia materials.

2. Written procedures, specific to the District, for operating, maintaining, diagnosing, troubleshooting, and repairing the hardware, software, and firmware if O&M references not used in class.

3. Command code, service code, and error code lists.

4. Tests, quizzes, and performance evaluations.

5. Warranty information, if applicable.

B. Reference Documents: documents used as sources of the material in the instructor guide shall be provided with the instructor guide submittal.

2.08 STUDENT GUIDE

A. Provide one copy of the student guide for each student plus two additional copies.

B. Student guides shall be separate from, and in addition to, the O&M manuals.

C. The student guide shall include:

1. Table of Contents, including titles and page numbers of each lesson. The guide will have a footer that includes the document title and page numbers.

2. Course timeline, to include in order:

   a. Lesson titles

   b. Time to teach each lesson

   c. Type of instruction employed in delivering each lesson, such as classroom, hands-on, or field.

3. Lesson contents, including lesson titles and objectives.

4. Materials students will refer to in class including but not limited to: slides, pictures, tables, charts, diagrams, written procedures, code lists, system address lists, and drawings

5. Course evaluation form.

D. Provide the District with changes and revisions to the student guide throughout the Contract and warranty.

2.09 TRAINING REPORTS

A. Maintain a roster of each class that includes: Class Name, Class Date(s), Instructor Name, Start Time, Location, Participant Employee ID No and Name with space for signature and final grade and submit after class sign-in to the District training department.

B. Within two days of completion of each training class, update the roster with student final grade and submit along with student evaluations of the training course to the District training department.

2.10 FINAL DELIVERABLES

A. After changes through staged training have been incorporated and approved, submit final approved deliverables for all courses consisting of the final versions of the following:

1. Instructor guides and attachments to the instructor guides, in electronic editable native format in accordance with current District standards.

2. Questions and Answers (Q&As) per Article 3.03.J herein compiled in electronic editable native format in accordance with current District standards.

3. Training aids and supporting documentation.

4. Self-paced, computer-based, or multimedia software and materials needed to deliver including licensing.

5. Other training materials and equipment that have not already been provided needed to deliver training courses.

PART 3 – EXECUTION

3.01 TRAINING LOCATION AND CLASSROOMS

A. Conduct training classes in facilities subject to District approval. Equip facilities with tables, chairs, equipment, and tools required to deliver each course. District facilities may be available upon request.

B. Secure access to field equipment required for class delivery.

C. Locations with District access or within close proximity to work locations shall be given higher priority when selecting a training location.

D. Plan for transportation between training locations during class delivery and after students have arrived.

E. An instructor training at a BART facility for more than two (2) weeks will be required to submit a photo ID and personal information for a background check to be performed and a BART contractor badge to be issued. Training conducted under two (2) weeks does not require a Department of Justice (DOJ) investigation and a temporary contractor badge will be issued.

3.02 TRAINING DEMONSTRATION

A. After approval of all training materials and equipment, schedule a training demonstration of each training course to demonstrate compliance with requirements herein.

1. Prior to scheduling of the demonstration class, confirm in writing that the instructor has been on the Jobsite and is proficient with the training course materials, training equipment, and knowledgeable of the details of the equipment installation and integration at the District.

2. Prior to scheduling of the demonstration class, verify in writing to training department that systems and equipment are working as designed.

3. Approved instructor guides, student training manuals, other training materials and training aids for the course shall be used in the training demonstrations.

4. The approved course shall be presented in its entirety to an evaluation team composed of District technical, supervisory, and training personnel.

5. Demonstration training does not count toward staged training.

6. The evaluation team will participate fully as students evaluating the course content, organization, and presentation for applicability and compliance with the requirements herein.

7. The evaluation team will prepare a list of nonconformances, and recommend either acceptance, acceptance with changes, or rejection of the training demonstration.

8. Document updates or requested changes that result from the demonstration class. Include how the change will be incorporated into the training materials or reason for not incorporating it for approval by the District training representative.

9. Required changes shall be made and approved prior to staged delivery.

10. The evaluation team will recommend to the District that all (when rejected), or a portion (when accepted with changes) of the training demonstration be repeated.

11. For TTT courses after the demonstration course is approved, deliver a TTT process as follows:

    a. Deliver the approved course to identified EDS.

    b. Review the instructor guide with the EDS after delivery of the course.

    c. Walk through how to configure training equipment and training aids in accordance with the instructor guide.

    d. Observe delivery by each EDS trained via TTT process until it is confirmed course is delivered as designed and accurate information provided.

e. Be available to answer questions from staged training until all staff are trained. Questions shall be answered within two calendar days of submission.

3.03 STAGED TRAINING

A. Unless identified as a TTT course in Attachment 1: Training Courses by Audience, all training delivery shall be the responsibility of the Contractor.

B. Staged training shall use approved training materials and training aids provided by the Contractor.

C. The maximum class size for classroom training shall be consistent with the maximum class size defined for the functional group receiving the training per Attachment 1: Training Courses by Audience.

D. The maximum class size for field and hands-on practice shall be four persons.

E. The training shall not exceed eight hours per day, including lunch and breaks.

F. Classes shall be scheduled on the three shifts (days, swing, graves) as required to train the number of staff working on that shift per Attachment 1: Training Courses by Audience. Concurrent training delivery on each shift may be required to meet project deadlines.

G. Class schedules shall be submitted to the District for approval at least four weeks prior to the projected start of training. Staged training shall be included on the schedule regardless of training delivery responsibility.

H. Train the number of staff identified in Attachment 1: Training Courses by Audience.

I. Provide sufficient training aids and materials for the number of students in the class.

J. During the delivery of training, gather unanswered questions from the classes, identify answers, and prepare a summary (appending to the last class list) of Q&As for distribution to training participants. Applicable information shall be incorporated into the final instructor guide and student guide materials prior to submission of final deliverable.

K. Have each participant complete a standard course evaluation form provided by District training department.

ATTACHMENT 1: TRAINING COURSE BY AUDIENCE

System or Equipment	Course Type	Staged Training Delivery	Delivery Method	Minimum Course Length (hours)	Audience	Audience Number by Shift			Maximum Class Size by Shift		
						Day	Swing	Grave	Day	Swing	Grave

Notes for completing the table:

- *System or equipment is broken out or grouped based on responsible District maintenance group.*
- *Course Type indicates which of the 5 types are delivered. A given system or equipment may have multiple course types. Include a separate line for each course type. Insert the appropriate code from the list below:*
  - *I = Installation* *O = System and Equipment Operation*
  - *C = System Configuration* *P = Primary Maintenance* *S=Secondary Maintenance*
- *Staged Training Delivery indicates whether it is the sole responsibility of the contractor OR the contractor will perform Train the Trainer and District will deliver staged training. Insert the appropriate code from the list below:*
  - *CON = Contractor delivered* *TTT = Contractor delivers train the trainer and District delivers*
- *Delivery Method lists the expected delivery method(s) for the training: lecture, demonstration, computer-based, hands-on practice. More than one Delivery Method may be applicable.*
- *Audience is the primary classification(s) for which the training will be created. Job Description of this classification is used for prerequisite planning.*
- *Audience Number by Shift is the total number of students who require training to be delivered on each shift.*
- *Maximum Class Size by Shift is the maximum number of students that can attend classroom training on each shift. Class sizes may need to be smaller due to District scheduling needs or hands-on practice requirements*

END OF SECTION 01 79 00

SECTION 01 81 13

SUSTAINABILITY REQUIREMENTS

PART 1 – GENERAL

1.01 SUMMARY

A. Work Included: BART Sustainability Requirements.

B. Related Sections:

1. Section 01 31 19, Project Meetings.
2. Section 01 32 16, Construction Progress Schedule.
3. Section 01 33 00, Submittal Procedures.
4. Section 01 33 23, Shop Drawings, Product Data, and Samples.
5. Section 01 57 00, Temporary Controls.
6. Section 01 60 00, Product Requirements.
7. Section 01 74 21, Waste Management.
8. Division 1 sections as referenced in this section.
9. Technical Specifications containing sustainability requirements as applicable for this Contract.

C. This section represents Sustainability Requirements for BART projects.

1.02 REFERECNCES

A. General: Comply with the applicable provisions of the current version of the referenced standards except as modified by governing codes and the Contract Documents. In the event of conflict between referenced standards, this specification or within themselves, the more stringent standard or requirement shall govern.

1. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)
2. Bay Area Air Quality Management District (BAAQMD)
3. California Green Building Standards Code California Code of Regulations, Title 24, Part 11 (CALGreen) Environmental Protection Agency (EPA)
4. Carpet and Rug Institute (CRI) (Green Label, Green Label Plus)
5. California Air Resources Board (ARB)

6. Forest Stewardship Council (FSC)

7. Green Seal

8. Illuminating Engineering Society of North America (IESNA)

9. Sheet Metal and Air Conditional National Contractor Association (SMACNA)

10. South Coast Air Quality Management District (SCAQMD)

11. United States Green Building Council (USGBC): Leadership in Energy and Environmental Design (LEEDTM) Green Building Rating System, 2009 Version.

1.03 DEFINITIONS

A. Agrifiber Products: Composite panel products derived from agricultural fiber

B. Biobased Product: As defined in the 2002 Farm Bill, a product determined by the Secretary to be a commercial or industrial product (other than food or feed) that is composed, in whole or in significant part, of biological products or renewable domestic agricultural materials (including plant, animal, and marine materials) or forestry materials.

C. Biobased Content: The weight of the biobased material divided by the total weight of the product and expressed as a percentage by weight.

D. Certificates of Chain-of-Custody: Certificates signed by manufacturers certifying that wood used to make products has been tracked through its extraction and fabrication to ensure that it was obtained from forests certified by a specified certification program.

E. Composite Wood: A product consisting of wood fiber or other plant particles bonded together by a resin or binder.

F. Construction and Demolition Waste: Includes solid wastes, such as building materials, packaging, rubbish, debris, and rubble resulting from construction, remodeling, repair, and demolition operations.

G. Light Pollution: Light that extends beyond its source such that the additional light is wasted in an unwanted area or in an area where it inhibits view of the night sky.

H. Recycled Content Materials: Products that contain pre-consumer or post-consumer materials as all or part of their feedstock.

I. Post-Consumer Recycled Content: The percentage by weight of constituent materials that have been recovered or otherwise diverted from the solid-waste stream after consumer use.

J. Pre-Consumer Recycled Content: Materials that have been recovered or otherwise diverted from the solid-waste stream during the manufacturing process. Pre-consumer content must be material that would not have otherwise entered the waste

stream as per Section 5 of the FTC Act, Part 260 “Guidelines for the Use of Environmental Marketing Claims”: www.ftc.gov/bcp/grnrule/guides980427

K. Regional Materials: Materials that are extracted, harvested, recovered, and manufactured within a radius of 250 miles (400 km) from the Project site.

L. Rapidly Renewable Materials: Materials from plants harvested within a 10-year or shorter cycle.

M. Salvaged or Reused Materials: Materials extracted from existing buildings in order to be reused in other buildings without being manufactured.

N. Sealant: Any material that fills and seals gaps between other materials.

O. Volatile Organic Compounds (VOCs): Any compound of carbon, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate, which participates in atmospheric photochemical reactions. Compounds that have negligible photochemical reactivity, listed in EPA 40 CFR 51.100(s), are also excluded from this regulatory definition.

1.04 SUBSTITUTIONS

A. The following substitution requirements apply to materials and assemblies that list Sustainability Requirements. For general substitution requirements, refer to Section 01 33 00, Submittal Procedures, Section 01 33 00, Shop Drawings, Product Data, and Samples, and Section 01 60 00, Product Requirements.

B. To substitute products that affect Sustainability Requirements, propose products that offer equivalent or increased environmental sensitivity and meet the intent of the Contract Documents. Substitutions that may affect Sustainability Requirements shall be clearly identified.

C. Inform Engineer in writing where Sustainability Requirements could detrimentally impact project cost, schedule or quality or where project conditions require alternate materials or procedures. This notice shall be given prior to the completion of the submittal schedule specified in Section 01 33 00.

D. Guidelines: Only one substitution for a product with Sustainability Requirements will be considered. If the substitution is rejected, provide the specified product. Submit the following for review by Engineer:

1. Product data, including manufacturer, website, and phone number.

2. Copy of VOC testing data (if applicable).

3. Description of the differences between the proposed substitution and the specified product related to Sustainability Requirements. Explain the environmental advantages of the proposed product as compared to the specified product.

4. The Contractor is responsible for re-submittals of calculations, documentation of products, or material substitutions that affect Sustainability Requirements.

5. Identify product substitution by Specification and affected Sustainability Requirements.

6. Give cost data comparing proposed substitution with specified product and amount of net change to Contract Sum.

7. State effect of substitution on construction schedule and changes required in other work of products.

E. Within 14 Days of substantial completion, provide all approved Substitution Request Forms related to this section.

1.05 SUBMITTALS

A. General: This section provides an overview of Sustainability Information submittals. Refer to technical specification sections for Sustainability Information to be submitted for specific products.

B. Schedule of submittals: Schedule shall be provided per Section 01 33 00. Not more than 30 Days after the effective date of Notice to Proceed, the General Contractor shall provide to the Engineer an updated schedule of submittals that includes cost and sustainability information. The Project Materials Cost Schedule shall be an electronic spreadsheet tabulating the total cost for the Project and the total cost of building materials used for the Project, as follows:

1. Schedule of materials costs for all materials to be submitted for the Project organized by specification section. Exclude labor costs and all mechanical, electrical, and plumbing (MEP) systems materials and labor costs. Include the following:

    a. Statement indicating total cost for materials used for Project in Divisions 03-10 and 31-32 excluding labor, overhead, and profit.

    b. Where materials cost breakdown is not available, use default value of 45 percent of total cost.

    c. Only include materials permanently installed in the project. Furniture should also be included where applicable.

    d. The spreadsheet shall include line items for each material including, the product name, the manufacturer of the material, and the product cost. The spreadsheet shall include line items for sustainability characteristics as applicable for each product as noted below:

        1) Salvaged or Reused Materials: Identify the reused or salvaged content being tracked for recycled content. As applicable, include the source or vendor and the product's replacement value. The spreadsheet shall provide a tabulation of the total combined salvaged/reused content value for all materials as a percentage of total materials costs.

2) Recycled Content: Identify the pre-consumer and post-consumer recycled content (as a percentage of the product's weight), the combined recycled content value (defined as the sum of the post-consumer recycled content value plus one-half of the pre-consumer recycled content value), and the source of the recycled content data. The spreadsheet shall provide a tabulation of the total combined recycled content value for all materials as a percentage of total materials costs.

3) Regional Materials: Identify each regional material, its manufacturing location, the distance of this location from the Project site, the source location for each raw material component of the material, and the distance of these extraction locations from the Project site. For materials with multiple materials sources, tabulate the percentage of the product by weight that meets both the extraction and manufacturer location criteria. The spreadsheet shall provide a tabulation of the total value of regional materials as a percentage of total materials costs.

4) Rapidly Renewable Products: Identify each rapidly renewable material, its source, and the percentage of the product (by weight) that meets the rapidly renewable criteria. The spreadsheet shall provide a tabulation of the total value of rapidly renewable materials as a percentage of total materials costs.

5) Certified Wood: Identify each wood-based material, identify which of these products (or components of products) are FSC certified, and provide the entity's Chain of Custody (COC) certification number. The spreadsheet shall provide a tabulation of the total value of FSC Certified wood as a percentage of total wood-based materials costs.

2. Project Materials Cost Schedule Progress Reports: The spreadsheet shall be updated and submitted every third month (or as otherwise directed by the Engineer) with the Contractor's Certificate and Application for Payment.

3. Provide final versions of the Project Materials Cost Schedule to the Engineer not more than 14 Days after Substantial Completion.

C. Within seven Days of Notice to Proceed, submit Contractor timeline for providing the following plans. The submittal dates for these plans, and any critical-path items related to these plans, shall be integrated into the Contract Schedule specified in Section 01 32 16, Construction Progress Schedule.

1. Stormwater Pollution Prevention Plan complying with Section 01 57 00, Temporary Controls.

2. Waste Management Plan complying with Section 01 74 21, Waste Management.

D. Sustainability Progress Reports: Concurrent with each Payment Application Form, specified in Section 01 20 00, Price and Payment Procedures, submit reports for the following:

1. Project Materials Cost Schedule Progress Reports: Updated spreadsheets as noted in Project Materials Cost Schedule section above. Frequency of these reports shall be as directed by Engineer.

2. Stormwater Pollution Prevention Plan inspection documentation as specified in Section 01 57 00, Temporary Controls.

3. Construction Waste Management: Waste reduction progress reports and logs complying with the requirements of Section 01 74 21, Waste Management.

E. Final Sustainability Reports: Provide the following within 14 Days of Substantial Completion:

1. Final Project Materials Cost Schedule

2. Final Summary of Solid Waste Disposal and Diversion complying with the requirements of Section 01 74 21, Waste Management.

3. SWPPP final approved annual report as specified in Section 01 57 00, Temporary Controls.

F. Product Sustainability Information: Furnish the following Sustainability Information submittals as noted in the applicable Technical Specifications sections. Sustainability Information shall be included in product submittals and shall not be submitted separately from other product information. No submittal is complete without formal verification by the Contractor that sustainability requirements for that product have been met:

1. Heat Island Effect:

   a. Site Paving: Submit manufacturer's cut sheets for all impervious paving materials, highlighting the Solar Reflectance Index (SRI) of the material. Submit cut sheets for all pervious paving materials.

   b. Roofing Materials: Submit manufacturer's cut sheets or product data highlighting the Solar Reflectance Index (SRI) of the material.

2. Exterior Lighting Fixtures: Submit cut sheets with manufacturer's data on exterior light pollution minimization, as specified in Section 26 50 00, Lighting.

3. Irrigation Systems: Submit manufacturer's cut sheets for permanent irrigation system components and for rainwater harvesting system components.

4. Water Conserving Fixtures: Submit manufacturer's cut sheets for water-consuming plumbing fixtures and fittings (toilets, urinals, faucets, showerheads, etc.) per Section 22 40 00, Plumbing Fixtures.

5. Process Water Use: Submit manufacturer's cut sheets for water-consuming commercial equipment highlighting water consumption performance, water use reduction measures, and corrosion inhibitors.

6. Elimination of Ozone-Depleting Substances: Submit manufacturer's cut sheets for cooling equipment, fire-suppression equipment, and insulation highlighting refrigerant or blowing agents per Section 23 81 00, Unitary HVAC Equipment; Section 21 22 00, Clean Agent Fire Extinguishing System; and Section 07 21 11, Building Insulation.

7. Appliances and Equipment: Submit manufacturer's product data for equipment and appliances, including office equipment, computers and printers, and electronics (excluding HVAC and lighting components) highlighting Energy Star certification.

8. On-Site Renewable Energy Systems: Submit cut sheets and manufacturer's product data for on-site renewable energy generating components and equipment, including documentation of output capacity.

9. Salvaged or Reused Materials: Submit documentation of each salvaged or reused material, the source or vendor of the material, the purchase price, and the replacement cost if greater than the purchase price.

10. Recycled Content: Submit documentation for all materials with recycled content (excluding MEP systems equipment and components) and include the following:

    a. Cost of each material or product, excluding cost of labor and equipment for installation per "Project Materials Cost Schedule" in the Submittals section above.

    b. Manufacturer's product data, product literature, or a letter from the manufacturer verifying the percentage of post-consumer and pre-consumer recycled content (by weight) of each material or product.

11. Regional Materials: Submit documentation of products or materials expected to contribute to the regional calculation (excluding MEP systems equipment and components) and include the following:

    a. Cost of each material or product, excluding cost of labor and equipment for installation per "Project Materials Cost Schedule" in the Submittals section above.

    b. Location of product manufacture and distance from point of manufacture to the Project Site.

    c. Location of point of extraction, harvest, or recovery for each raw material in each product and distance from the point of extraction, harvest, or recovery to the Project Site.

12. Rapidly Renewable Products: Submit documentation of products or materials expected to contribute to the rapidly renewable product calculation and include the following:

    a. Cost of each material or product, excluding cost of labor and equipment for installation per "Project Materials Cost Schedule" in the Submittals section above.

    b. Manufacturer's product data, product literature, or a letter from the manufacturer verifying that rapidly renewable materials and indicate the percentage (by weight) of the rapidly renewable components contained in the candidate products, along with the costs of each of these materials, excluding labor and delivery costs.

13. Certified Wood: Submit documentation of wood-based materials and include the following:

    a. Cost of each material or product, excluding cost of labor and equipment for installation per “Project Materials Cost Schedule” in the Submittals section above.

    b. Product data and certificates of chain-of-custody of certified-wood products by an FSC-accredited certification body for FSC 1.2 “Principles and Criteria.” Visit www.fscus.org/green_building for more information.

14. Adhesives and Sealants: Submit documentation of field-applied adhesives, sealants, and sealant primer product, and include:

    a. Manufacturer’s name, product name, specific VOC data (in g/L less water) for each product, and the corresponding allowable VOC from the referenced standard.

    b. Manufacturer cut sheets, literature, letter, or MSDS for each adhesive/sealant, with the VOC content (g/L less water) circled. VOC content shall be calculated according to 40 CFR 59, Subpart D (EPA method 24).

    c. Manufacturers’ documentation verifying all adhesives used to apply laminates, whether shop-applied or field-applied, contain no urea-formaldehyde.

15. Paints and Coatings: Submit documentation for field-applied paints and coatings and include:

    a. Manufacturer’s name, product name, specific VOC data (in g/L less water) for each product, and the corresponding allowable VOC from the referenced standard.

    b. Manufacturer cut sheets, literature, letter, or MSDS for each paint or coating, with the VOC content (g/L less water) circled, calculated according to 40 CFR 59, Subpart D (EPA method 24).

16. Floorcoverings: Submit documentation for floorcovering systems, including carpet, resilient flooring, and engineered wood and bamboo flooring and include indoor emissions testing information as specified in the applicable technical specifications sections.

17. Composite Wood and Agrifiber Binders and Glues: Submit documentation for all composite wood and agrifiber products (including but not limited to particleboard, wheatboard, strawboard, agriboard products, engineered wood components, solid-core wood doors, OSB, MDF, and plywood products) and include:

    a. Manufacturer’s product data verifying that products contain no urea-formaldehyde resins.

18. Entryway Systems: Submit manufacturer’s cut sheets for walk-off systems installed to capture particulates, including permanently installed grates, grilles, slotted systems, direct glue-down walk-off mats, and non-permanent roll-out

mats. Include shop drawings indicating length of walk-off system in direction of travel.

19. Air Filtration: Submit manufacturer's cut sheets and product information for filtration media per Section 23 81 00, Unitary HVAC Equipment.

20. Mercury in Lighting: Submit manufacturer's cut sheets or product data for fluorescent or HID lamps highlighting mercury content per Section 26 50 00, Lighting.

21. Lighting Controls: Submit manufacturer's cut sheets and shop drawing documentation highlighting lighting controls systems components.

22. Thermal Comfort Controls: Submit manufacturer's cut sheets and shop drawing documentation highlighting thermal comfort-control systems components.

23. Blended Cement: Submit the following documentation for concrete mixes:

    a. Copies of concrete design mixes for installed concrete

    b. Copies of typical regional baseline concrete design mixes for each compressive strength used on the Project

    c. Quantities in cubic yards of each installed concrete mix

24. Gypsum Wall Board: Submit manufacturer's cut sheets or product data verifying that all gypsum wallboard products are moisture and mold-resistant.

25. Fiberglass Insulation: Submit manufacturer's cut sheets or product data verifying that fiberglass batt insulation contains no urea-formaldehyde.

26. Green Housekeeping: Submit documentation of cleaning products and janitorial paper products used during construction meet the VOC limits and content requirements per Section 01 74 14, Cleaning.

1.06 PROJECT MEETINGS

A. General: Refer to Section 01 31 19, Project Meetings for general project meeting requirements.

B. Preconstruction Meeting: Sustainability Requirements shall be an agenda item at the pre-construction meeting. The purpose of this agenda item is to develop an understanding of the Project's Sustainability Requirements and coordination of the Contractor's management of these requirements.

C. Construction Job Conferences: The status of compliance with the Sustainability Requirements of these specifications will be an agenda item at all regular job meetings conducted during the course of work at the site.

1.07 DELIVERY, STORAGE AND HANDLING

A. General: Package, transport, and store materials in accordance with Section 01 60 00, Product Requirements.

B. Packaging: Deliver materials in recyclable or in reusable packaging such as cardboard, wood, paper, or reusable blankets, which will be reclaimed by supplier or manufacturer for recycling.

1. General: Minimize packaging materials to maximum extent possible while still ensuring protection of materials during delivery, storage, and handling:

   a. Unacceptable Packaging Materials: Polyurethane, polyisocyanate, polystyrene, polyethylene, and similar plastic materials such as “foam” plastics and “shrink-fit” plastics.

2. Reusable Blankets: Deliver and store materials in reusable blankets and mats reclaimed by manufacturers or suppliers for reuse where program exists or where program can be developed for such reuse.

3. Pallets: Where pallets are used, suppliers shall be responsible to ensure pallets are removed from site for reuse or for recycling.

4. Corrugated Cardboard and Paper: Where paper products are used, recycle as part of construction waste management recycling program, or return to material's manufacturer for use by manufacturer or supplier.

5. Sealants, Paint, Primers, Adhesives, and Coating Containers: Return to supplier or manufacturer for reuse where such program is available.

PART 2 – PRODUCTS

2.01 PRODUCT SUSTAINABILITY REQUIREMENTS

A. Site Clearing: Topsoil and vegetated material shall be salvaged and reused on-site whenever possible. See Section 31 00 00, Earthwork and Section 31 11 00, Clearing and Grubbing.

B. Site Paving: Refer to Division 32 paving sections for required Solar Reflectance Index for impervious paving.

C. Roofing Materials: Refer to Division 8 roofing specifications for required Solar Reflectance Index for roofing systems.

D. Exterior Lighting Fixtures: Refer to Section 26 50 00, Lighting for requirements to minimize exterior light pollution.

E. Irrigation Systems: Refer to Section 32 84 00, Planting Irrigation for water conservation requirements.

F. Water-Conserving Fixtures: Refer to Division 22 for maximum flow and flush rates for specific fixtures.

G. Process Water Use: Employ strategies that in aggregate result in 20 percent less water use than the EPACT 2005 process water use baseline for the project. For equipment not addressed by EPACT 2005, equipment performance requirements may be proposed, provided documentation supporting the proposed benchmark or industry standard is submitted.

H. Elimination of Ozone-Depleting Substances: Refer to Section 23 81 00, Unitary HVAC Equipment, Section 21 22 00, Clean Agent Fire Extinguishing System, and Section 07 21 11, Building Insulation.

I. Appliances and Equipment: All Energy Star eligible equipment and appliances, including office equipment, computers and printers, and electronics (excluding HVAC and lighting components), shall be qualified by EPA's Energy Star or EPEAT programs.

J. Outdoor Air Delivery Monitoring: Refer to Section 23 09 00, Instrumentation and Control for HVAC for HVAC monitoring requirements.

2.02 RECYCLED CONTENT OF MATERIALS

A. Provide building materials with recycled content such that post-consumer recycled content value plus half the pre-consumer recycled content value constitutes a minimum of 20 percent of the cost of materials used for the Project, exclusive of all MEP equipment, labor, and delivery costs. The Contractor shall make all attempts to maximize the procurement of materials with recycled content.

B. The post-consumer recycled content value of a material shall be determined by dividing the weight of post-consumer recycled content by the total weight of the material and multiplying by the cost of the material.

C. The pre-consumer recycled content value of a material shall be determined by dividing the weight of pre-consumer recycled content by the total weight of the material and multiplying by the cost of the material.

D. Do not include mechanical and electrical components in the calculations.

E. Do not include labor and delivery costs in the calculations.

F. Recycled content of materials shall be defined according to the Federal Trade Commission's "Guide for the Use of Environmental Marketing Claims," 16 CFR 260.7 (e).

G. Utilize all on-site existing paving materials that are scheduled for demolition as granulated fill, and include the cost of this material had it been purchased in the calculations for recycled content value.

2.03 REGIONAL MATERIALS

A. Target percentages for regional materials will vary by project. Where possible, contractor shall select materials harvested and manufactured regionally, within a

500-mile “adjusted radius” of the project site. The “adjusted radius” allows an adjustment factor for transportation with lower environmental impact. Rail miles are multiplied by a factor of 3; ship miles are multiplied by a factor of 15:

1. The regional content fraction of a material shall be determined by the proportion by weight of its constituents that are extracted, harvested, or sourced within 500 miles of the project site. The regional fraction of the material is then multiplied by the cost of the material to determine the regional content value. If a material is processed or manufactured more than 500 miles from the project site, then no part of the material can be counted for regional content value.

B. The Contractor shall make all attempts to maximize the procurement of materials within this radius. In the event that materials comprising a significant percentage of the total project materials (5 percent or more) cannot be regionally sourced, contractor shall provide the Engineer with an explanation in writing.

2.04 RAPIDLY RENEWABLE MATERIALS

A. Biobased Products:

1. Use only biobased concrete form-release products.

2. Solid Wood Products: All new solid-wood-based materials will be certified as “FSC 100 percent” by an independent third party in accordance with FSC Forest Stewardship Council “Principles and Criteria” and will have received Chain-of-Custody Certification as certified by an accredited certification group such as Smartwood or Scientific Certification Systems (SCS).

3. Other Wood Products: All other new wood-based materials will be certified by an independent third party in accordance with any of the following standards:

    a. FSC: Forest Stewardship Council “Principles and Criteria” and has received Chain-of-Custody Certification as certified by an accredited certification group such as Smartwood or Scientific Certification Systems (SCS).

4. Preservative-treated lumber with chromated copper arsenate (CCA) treatments is not permitted, and lumber with copper-based treatments (such as ACQ) is permitted only for ground-contact applications.

5. Wood-based materials include but are not limited to the following materials (when made from wood), engineered wood products, or wood-based panel products:

    a. Rough carpentry

    b. Miscellaneous carpentry

    c. Heavy timber construction

    d. Wood decking

    e. Particleboard

    f. Plywood

g. Metal-plate-connected wood trusses

h. Structural glued-laminated timber

i. Finish carpentry

j. Architectural woodwork

k. Wood paneling

l. Wood veneer wall covering

m. Wood flooring

n. Wood lockers

o. Wood cabinets

p. Wood doors

q. Non-rented temporary construction, including bracing, concrete formwork, pedestrian barriers, and temporary protection.

r. Furniture (if included consistently in total project material cost).

B. Brominated Flame Retardants: brominated flame retardants in new furniture including cushioned office seating and lounge seating are not permitted.

2.05 LOW-EMITTING MATERIALS

A. Adhesives and Sealants:

1. All adhesives, adhesive bonding primers, adhesive primers, sealants, sealant primers, and caulks shall comply with local or regional air pollution control or air quality management district rules where applicable, or SCAQMD Rule #1168 VOC limits, as shown in table below. VOC content shall be calculated according to 40 CFR 59, Subpart D (EPA method 24).

2. Aerosol adhesives, sealants, and caulking compounds (in units of product, less packaging, which do not weigh more than one pound and do not consist of more than 16 fluid ounces) shall comply with statewide VOC standards California Code of Regulations, Title 17, commencing with section 94507.

a.	Carpet Adhesives	50 g/L
b.	Carpet Pad Adhesives	50 g/L
c.	Wood Flooring Adhesives	100 g/L
d.	Rubber Floor Adhesives	60 g/L
e.	Subfloor Adhesives:	50 g/L
f.	Ceramic Tile Adhesives:	65 g/L

g.	VCT and Sheet Vinyl Adhesives:	50 g/L
h.	Gypsum Board and Panel Adhesives:	50 g/L
i.	Cove Base Adhesives:	50 g/L
j.	Multipurpose Construction Adhesives:	70 g/L
k.	Structural Glazing Adhesives and Compounds:	100 g/L
l.	Single-Ply Roofing Membrane Adhesives	250 g/L
m.	Other Adhesive not specifically listed	50 g/L
n.	PVC Welding Compounds	285 g/L
o.	CPVC Welding Compounds:	270 g/L
p.	ABS Welding Compounds:	325 g/L
q.	Adhesive Primer for Plastic:	250 g/L
r.	General Contact Adhesive:	80 g/L
s.	Special Purpose Contact Adhesive (used to bond melamine covered board, metal, unsupported vinyl, Teflon, ultra-high molecular weight polyethylene, rubber or wood veneer 1/16 inch or less in thickness to any surface):	250 g/L
t.	Structural Wood Member Adhesive	140 g/L
u.	Top and Trim Adhesive	250 g/L
	Substrate Specific Applications	
v.	Metal to Metal Adhesives	30 g/L
w.	Plastic Foam Adhesives:	50 g/L
x.	Adhesives for Porous Materials (Except Wood):	50 g/L
y.	Wood Glues	30 g/L
z.	Millwork and Casework Adhesives	20g/L
aa.	Fiberglass Adhesives	80 g/L

	Sealants	
bb.	Architectural Sealants	250 g/L
cc.	Nonmembrane Roof Sealants	300 g/L
dd.	Roadway	250 g/L
ee.	Single-Ply Roof Membrane Sealants	450 g/L
ff.	Other Sealants	420 g/L
	Sealant Primers	
gg.	Sealant Primers for Nonporous Substrates	250 g/L
hh.	Sealant Primers for Porous Substrates	775 g/L
ii.	Carpet Seam Sealer:	50g/L
jj.	Modified Bituminous Sealant Primers	500 g/L
kk.	Other Sealant Primers	750 g/L
	Aerosol Adhesive	
ll.	Aerosol Adhesive, General Purpose Mist Spray:	65% by weight
mm.	Aerosol Adhesive, General Purpose Web Spray:	55 % by weight.
nn.	Special Purpose Aerosol Adhesive (All Types):	70% by weight.

3. Interior sealants shall not contain: mercury, butyl rubber, neoprene, SBR (styrene butadiene rubber), or nitrile.

4. Sealants and glazing compounds shall not contain aromatic solvents (organic solvent with a benzene ring in its molecular structure), fibrous talc, asbestos, formaldehyde, halogenated solvents, mercury, lead, cadmium, or hexavalent chromium.

5. Adhesives shall not contain urea-formaldehyde.

B. Paints and coatings:

1. Architectural paints and coatings shall comply with VOC limits in Table 1 of the ARB Architectural Coatings Suggested Control Measure, as shown in the Table below. VOC limits for paints and coatings shall be calculated according to 40 CFR 59, Subpart D (EPA method 24).

2. Aerosol paints and coatings shall meet the Project-Weighted MIR Limits for ROC in section 94522(a)(3) and other requirements, including prohibitions on use of toxic compounds and ozone-depleting substances, in sections 94522(c)(2) and (d)(2) of the California Code of Regulations, Title 17, commencing with section 94507; and in areas under the jurisdiction of the Bay Area Air Quality Management District additionally comply with the percent VOC by weight of product limits of Regulation 8 Rule 49.

3. Table of Allowable VOCs for Paints and Coatings.

a.	Flat Paints, Coatings, and Primers:	50 g/L
b.	Nonflat Paints, Coatings, and Primers	100 g/L
c.	Nonflat – High Gloss Coatings	150 g/L
d.	Aluminum Roof Coatings	400 g/L
e.	Basement Specialty Coatings	400 g/L
f.	Bituminous Roof Coatings	50 g/L
g.	Bituminous Roof Primers	350 g/L
h.	Bond Breakers	350 g/L
i.	Concrete Curing Compound	350 g/L
j.	Concrete Sealer	100 g/L
k.	Garage Deck/Driveway Sealer	50 g/L
l.	Dry-Fog Coatings:	400 g/L
m.	Faux Finishing Coatings	350 g/L
n.	Fire Resistive Coatings	350 g/L
o.	Floor Coatings	100 g/L
p.	Form Release Agents:	250 g/L
q.	Graphic Arts Coatings (sign paints)	500 g/L
r.	High Temperature Coatings	420 g/L
s.	Industrial Maintenance Coatings	250 g/L.
t.	Low Solids Coatings (includes water and exempt)	120 g/L
u.	Magnesite Cement Coatings	450 g/L
v.	Mastic Texture Coatings	100 g/L
w.	Metallic Pigmented Coatings	500 g/L

x.	Multi-color Coatings	250 g/L
y.	Pretreatment Wash Primers:	420 g/L
z.	Primers, Sealers, and Undercoaters	100 g/L
aa.	Reactive Penetrating Sealers	350 g/L
bb.	Recycled Coatings	250 g/L
cc.	Roof Coatings	50 g/L
dd.	Rust Preventative Coatings	250 g/L
ee.	Stains	250 g/L.
ff.	Stone Consolidants	450 g/L
gg.	Traffic Marking Coatings	100 g/L
hh.	Tub and Tile Refinish Coatings	420 g/L
ii.	Waterproofing Membranes	250 g/L
jj.	Wood Coatings	275 g/L
kk.	Wood Preservatives	350 g/L
ll.	Zinc-Rich Industrial Maintenance Primers:	340 g/L

4. Interior paints shall not contain antimicrobial additives (such as fungicides and biocides).

5. Interior field-applied varnishes and lacquers are not permitted.

6. Clear wood finishes, floor coatings, stains, sealers, and shellacs for interior elements shall comply with South Coast Air Quality Management District (SCAQMD) Rule 1113, Architectural Coatings, rules in effect on January 1, 2004:

    a. (Exterior) Clear Wood Finishes, Varnishes: 350 g/L

    b. (Exterior) Clear Wood Finishes, Lacquers: 550 g/L

    c. Floor Coatings: 100 g/L

    d. (Exterior) Shellacs, Clear: 730 g/L

    e. (Exterior), Pigmented: 550 g/L

    f. Stains: 250 g/L

    g. Waterproofing Sealers: 250 g/L

h. Sanding Sealers: 275 g/L

i. All Other Sealers: 200 g/L

7. Aromatic Compounds: Paints and coatings shall not contain more than 1.0 percent by weight total aromatic compounds (hydrocarbon compounds containing one or more benzene rings).

8. Restricted Components: Paints and coatings shall not contain any of the following per Green Seal Standard GS-11:

   a. Acrolein
   b. Acrylonitrile
   c. Antimony
   d. Benzene
   e. Butyl benzyl phthalate
   f. Cadmium
   g. Di (2-ethylhexyl) phthalate
   h. Di-n-butyl phthalate
   i. Di-n-octyl phthalate
   j. 1,2-dichlorobenzene
   k. Diethyl phthalate
   l. Dimethyl phthalate
   m. Ethylbenzene
   n. Formaldehyde
   o. Hexavalent chromium
   p. Isophorone
   q. Lead
   r. Mercury
   s. Methyl ethyl ketone
   t. Methyl isobutyl ketone
   u. Methylene chloride
   v. Naphthalene
   w. Toluene (methylbenzene)

x. 1,1,1-trichloroethane

y. Vinyl chloride

z. Xylene

C. Flooring systems: Floorcovering systems, including carpet, resilient flooring, and engineered wood and bamboo flooring shall meet or exceed the indoor emissions criteria as specified in the applicable technical specifications sections.

D. Composite Wood and Agrifiber Binders: composite wood, agrifiber products, and wood doors shall contain no urea-formaldehyde resins.

E. Fiberglass Insulation: Fiberglass batt insulation shall contain no formaldehyde-based binders or shall be third-party certified for conformance with Greenguard Gold Certification or Indoor Advantage Gold.

F. Duct Acoustical Insulation: Mechanical sound insulation materials within the duct shall consist of an impervious, non-porous coating that prevents dust from accumulating in the insulating materials.

G. Green Housekeeping: Refer to Section 01 74 14, Cleaning for green cleaning requirements.

PART 3 – EXECUTION

3.01 FIELD EXECUTION OF SUSTAINABILITY REQUIREMENTS

A. The contractor is responsible for ensuring proper field execution of all Sustainability Requirements, submittal requirements; communication with sub-contractors of all requirements; and submission of all documentation in a timely manner.

B. Contractor shall notify the Engineer immediately of failure to meet any stated Sustainability Requirement.

3.02 CONSTRUCTION WASTE MANAGEMENT

A. Implement the Construction Waste Management Plan (CWMP), as defined in Section 01 74 21, Waste Management.

END OF SECTION 01 81 13

SECTION 02 41 00

DEMOLITION

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Permits.

B. Site conditions.

C. Materials, equipment, and facilities.

D. Preservation of reference markers.

E. Demolition.

F. Removal.

G. Salvage.

H. Disposal of removed materials and debris.

1.02 RELATED SECTIONS

A. Temporary facilities, such as fences, barricades, warning lights, and other temporary safety measures, are specified in Section 01 52 00, Construction Facilities.

B. Dust control is specified in Section 01 57 00, Temporary Controls.

C. Selective demolition and removal for renovation of existing buildings, structures, and facilities are specified in Section 02 41 19, Selective Structure Demolition.

D. Removal of vegetation and trees is specified in Section 31 11 00, Clearing and Grubbing.

1.03 MEASUREMENT AND PAYMENT

A. Measurement:

1. Demolition will be measured for payment by the lump-sum method, acceptably performed and completed.

2. Material and placement for backfill will be measured separately for payment as specified in Section 31 00 00, Earthwork.

B. Payment:

1. Demolition will be paid for at the Contract lump-sum price as indicated in the Bid Schedule of the Bid Form.

2. Compacted backfill will be paid for as specified in Section 31 00 00, Earthwork.

1.04 REFERENCES

A. American National Standards Institute (ANSI):

1. ANSI A10.6 Safety and Health Program Requirements for Demolition Operations

B. State of California, Department of Transportation (Caltrans), Standard Specifications, Section 15, Existing Facilities

1.05 REGULATORY REQUIREMENTS

A. In addition to the foregoing referenced standards, the regulatory requirements that govern the work of this Section include the following governing codes:

1. California Code of Regulations (CCR), Title 8, Division 1, Chapter 4, Subchapter 4, Construction Safety Orders.

2. California Code of Regulations (CCR), Title 24, Part 2, California Building Code, Chapter 33, Safeguards During Construction.

1.06 DESCRIPTION

A. Demolition as follows:

1. Buildings and structure foundations, footings, and foundation systems shall be completely removed.

2. Utility services to facilities to be removed or demolished shall be disconnected, cut, and capped.

B. Removal of at-grade structures, such as existing pavements, curbs, gutters, sidewalks, and designated utility structures.

1.07 PERMITS

A. The Contractor shall obtain all special permits and licenses and give all notices required for performance and completion of the demolition and removal work, hauling, and disposal of debris.

1.08 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Demolition Plan: Submit a comprehensive demolition plan, describing the proposed sequence, methods, and equipment for demolition, removal, and disposal of structure(s); include salvage if required. Do not proceed with demolition until the Engineer has given written approval of the demolition plan.

1. Shop Drawings: Include drawings in plan of all structures to be demolished. Indicate stages or phases of the demolition work.

C. Permits: Submit copies of demolition, hauling, and debris disposal permits and notices for record purposes. Include description of proposed haul routes.

D. Utility Severance Certificates: Provide certificates, issued by the utility owners, of severance of utility services for record purposes.

E. Private Property Owner's Release: If material demolished and removed from the site will be deposited on private property, submit two copies of written releases not more than 15 Days before the start of work. Releases shall absolve the District from responsibility in connection with the depositing of material on private property, and shall be signed by the owners of such property on which the material will be deposited.

F. Record Documents: Provide copies of all approved submittals, specified herein, for record purposes in accordance with the requirements of Section 01 78 39, Project Record Documents.

1.09 SITE CONDITIONS

A. Protection of Persons and Property:

1. Install chain link fencing around the area of demolition work as specified in Section 32 31 13, Chain Link Fences and Gates. Comply with applicable requirements of Section 01 52 00, Construction Facilities.

2. Erect and maintain temporary bracing, shoring, lights, barricades, signs, and other measures as necessary to protect the public, workers, and adjoining property from damage from demolition work, all in accordance with applicable codes and regulations.

3. Open depressions and excavations occurring as part of this work shall be barricaded and posted with warning lights when accessible through adjacent property or through public access. Operate warning lights during hours from dusk to dawn each day and as otherwise required.

4. Protect utilities, pavements, and facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by demolition operations.

B. Protection of Utilities:

1. Protect active sewer, water, gas, electric, and other utilities; and drainage and irrigation lines indicated or, when not indicated, found or otherwise made known to the Contractor before or during demolition work. If utility is damaged, immediately notify the utility owner for corrective action.

2. Arrange with and perform work required by utility companies and municipal departments for discontinuance or interruption of utility services due to demolition work.

C. Noise and Dust Abatement: Comply with requirements specified in Section 01 57 00, Temporary Controls, and the following:

1. Provide continuous noise and dust abatement as required to prevent disturbance and nuisance to the public and workers and to the occupants of adjacent premises and surrounding areas. Dampen or cover areas affected by demolition operations as necessary to prevent dust nuisance.

2. When a certain level of noise is unavoidable because of the nature of the work or equipment involved, and such noise is objectionable to the occupants of adjacent premises, make arrangements with the jurisdictional authorities to perform such work or operate such equipment at the most appropriate time periods of the day. Provide abatement measures to the extent feasible and practicable.

D. Unknown Conditions:

1. The Contract Drawings and related documents may not represent all surface conditions at the site and adjoining areas. The known surface conditions are as indicated, and shall be compared with actual conditions before commencement of work.

2. Existing utilities and drainage systems below grade are located from existing documents and from surface facilities such as manholes, valve boxes, area drains, and other such surface fixtures.

3. If existing active services encountered are not indicated or otherwise made known to the Contractor and interfere with the permanent facilities under construction, notify the Engineer in writing, requesting instructions on their disposition. Take immediate steps to ensure that the service provided is not interrupted, and do not proceed with the work until written instructions are received from the Engineer.

4. Thickness of existing pavements are from previous construction documents, and do not imply the actual depth or thickness of the total pavement or base material, where it occurs. Remove pavement of whatever thickness as required.

PART 2 – PRODUCTS

2.01 MATERIALS, EQUIPMENT, AND FACILITIES

A. The Contractor shall furnish all materials, tools, equipment, devices, appurtenances, facilities, and services as required for performing the demolition and removal work.

B. Materials used for backfill shall conform to the requirements for backfill of Section 31 00 00, Earthwork.

PART 3 – EXECUTION

3.01 PRESERVATION OF REFERENCE MARKERS

A. Record the locations and designation of survey markers and monuments prior to their removal. Provide three reference points for each survey marker and monument removed, established by a licensed civil engineer or land surveyor currently registered in the State of California.

B. Store removed markers and monuments during demolition work, and replace them upon completion of the work. Re-establish survey markers and monuments in conformance with the recorded reference points. Forward to the Engineer a letter verifying re-establishment of survey markers and monuments, signed by a licensed civil engineer or land surveyor currently registered in the State of California.

3.02 DEMOLITION

A. Perform demolition in accordance with the approved Demolition Plan. Perform demolition work in accordance with ANSI A10.6 and the California Code of Regulations, Title 8 and Title 24, as applicable.

B. Cap or plug sanitary sewer in accordance with the utility owner’s standard details and instructions. Cap and plug pipe and other conduits abandoned due to demolition, with approved type caps and plugs as required by the utility owners.

C. Backfill and compact depressions caused by excavations, demolition, and removal in accordance with applicable requirements of Section 31 00 00, Earthwork.

3.03 REMOVAL

A. Remove existing pavements, structures, and site improvements that interfere with new construction, where demolition is not indicated. Coordinate as required with the work of Section 31 11 00, Clearing and Grubbing.

B. Remove walls and masonry construction to a minimum depth of two feet below existing ground level in areas where such items do not interfere with new construction.

C. Slabs may be broken for drainage and left in place where they are below grade and are not detrimental to the structural integrity of the fill or structure to be placed above, as determined by the Engineer.

3.04 SALVAGE

A. Salvage or reuse materials and equipment as indicated on the Contract Drawings and as specified in the Contract Specifications.

B. Protect metallic coatings on salvaged items. Remove adhering concrete from salvaged items.

C. Repair, or replace with new material, salvaged material damaged or destroyed due to Contractor's negligence, as determined by the Engineer.

3.05 DISPOSAL OF REMOVED MATERIALS AND DEBRIS

A. Dispose of removed materials, waste, trash, and debris in a safe, acceptable manner, in accordance with applicable laws and ordinances and as prescribed by authorities having jurisdiction.

B. Burying of trash and debris on the site will not be permitted. Burning of trash and debris at the site will not be permitted.

C. Remove trash and debris from the site at frequent intervals so that their presence will not delay the progress of the work or cause hazardous conditions for workers and the public.

D. Removed materials, trash, and debris shall become the property of the Contractor and shall be removed from the District's property and disposed of in a legal manner. Location of disposal site and length of haul shall be the Contractor's responsibility.

3.06 CLEANUP

A. Provide a clean and orderly site at all times in accordance with Section 01 74 14, Cleaning.

END OF SECTION 02 41 00

SECTION 02 41 19

SELECTIVE STRUCTURE DEMOLITION

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Inspection.

B. Demolition.

C. Cutting.

D. Salvaging.

E. Initial building cleaning.

F. Disposal of debris.

G. Restoration of existing structures and facilities.

H. Field Quality Control.

1.02 RELATED SECTIONS

A. Temporary facilities, such as fences, barricades, warning lights, and other temporary safety measures, are specified in Section 01 52 00, Construction Facilities. Provide such additional temporary facilities as may be required to facilitate continuous station or building operations during transitional construction work.

B. Dust control is specified in Section 01 57 00, Temporary Controls.

1.03 MEASUREMENT AND PAYMENT

A. Measurement: Selective demolition will be measured for payment by the lump-sum method, acceptably performed and completed.

B. Payment: Selective demolition will be paid for at the Contract lump-sum price, as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. American National Standards Institute (ANSI):

1. ANSI A10.6 Safety and Health Program Requirements for Demolition Operations

1.05 REGULATORY REQUIREMENTS

A. In addition to the foregoing referenced standards, the regulatory requirements which govern the work of this Section include the following governing codes:

1. California Code of Regulations (CCR), Title 8, Division 1, Chapter 4, Subchapter 4, Construction Safety Orders.

2. California Code of Regulations (CCR), Title 24, Part 2, California Building Code, Chapter 33, “Safeguards During Construction.”

1.06 DESCRIPTION

A. The station or building involved in this work will be in continuous operation during the construction period. This will require that the Contractor plan the Work carefully to work around unavoidable obstacles in the prosecution of the Work. It will require further that the Contractor complete some new construction facilities required in the renovation work before removing existing like facilities during transitional work.

B. Utility services to facilities to be removed or demolished shall be disconnected, cut, and capped, as required.

C. The work includes restoration of existing structures and facilities to remain in place that are damaged by demolition and removal operations.

1.07 PERMITS

A. The Contractor shall obtain special permits and licenses required for the work at no cost to the District, and give all notices required for performance and completion of the selective demolition and removal work, hauling, and disposal of debris.

1.08 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Selective Demolition Plan: Submit a comprehensive selective demolition plan, describing the proposed sequence, methods, and equipment for demolition, removal, and disposal of structure(s); include salvage if required. Do not proceed with demolition work until the Engineer has approved the selective demolition plan.

C. Permits: Submit copies of demolition, hauling, and debris disposal permits and notices for record purposes. Include description of proposed haul routes.

D. Utility Severance Certificates: Provide certificates, issued by the utility owners, of severance of utility services for record purposes.

E. Private Property Owner's Release: If material demolished and removed from the site will be deposited on private property, submit two copies of written releases not more than 15 Days before the start of work. Releases shall absolve the District from responsibility in connection with the depositing of material on private property, and shall be signed by the owners of such property on which the material will be deposited.

F. Record Documents: Provide copies of all approved submittals, specified herein, for record purposes in accordance with the requirements of Section 01 78 39, Project Record Documents.

1.09 SITE CONDITIONS

A. Protection of Persons and Property: Erect and maintain temporary bracing, shoring, lights, barricades, baffles, curtains, signs, and other measures as necessary to protect the public, workers, and adjoining property from damage from demolition work, all in accordance with applicable codes and regulations. Conform also with applicable requirements of Section 01 57 00, Temporary Controls.

B. Protection of Utilities:

1. Protect active sewer, water, gas, electric, and other utilities; and drainage and irrigation lines indicated or, when not indicated, found or otherwise made known to the Contractor before or during demolition work. If utility is damaged, immediately notify the utility owner for corrective action.

2. Arrange with and perform work required by utility companies and municipal departments for discontinuance or interruption of utility services due to demolition work.

C. Noise and Dust Abatement: Comply with requirements specified in Section 01 57 00, Temporary Controls, and the following:

1. Provide continuous noise and dust abatement as required to prevent disturbance and nuisance to the public and workers and to the occupants of adjacent premises and surrounding areas. Dampen or cover areas affected by demolition operations as necessary to prevent dust nuisance.

2. When a certain level of noise is unavoidable because of the nature of the work or equipment involved, and such noise is objectionable to the occupants of adjacent premises, make arrangements with the jurisdictional authorities to perform such work or operate such equipment at the most appropriate time periods of the day. Provide abatement measures to the extent feasible and practicable.

D. Unknown Conditions:

1. The Contract Drawings and related documents may not represent all surface conditions at the site and adjoining areas. The known surface conditions are as indicated, and shall be compared with actual conditions before commencement of work.

2. Existing utilities and drainage systems below grade are located from existing documents and from surface facilities such as manholes, valve boxes, area drains, and other such surface fixtures.

3. If existing active services encountered are not indicated or otherwise made known to the Contractor and interfere with the permanent facilities under construction, notify the Engineer in writing, requesting instructions on their disposition. Take immediate steps to ensure that the service provided is not interrupted, and do not proceed with the work until written instructions are received from the Engineer.

PART 2 – PRODUCTS

2.01 MATERIALS, EQUIPMENT, AND FACILITIES

A. The Contractor shall furnish all materials, tools, equipment, devices, appurtenances, facilities, and services as required for performing the selective demolition and removal work.

B. Materials forming portions of the structure indicated to be removed shall become the Contractor's property, and the Contractor shall be responsible for their removal from the site.

PART 3 – EXECUTION

3.01 INSPECTION

A. Prior to starting selective demolition operations, perform a thorough inspection of the building and premises, and report to the Engineer any defects and structural weaknesses of existing construction and of improvements to remain.

B. Examine areas affected by the Work of this Section and verify the following conditions:

1. Disconnection of utilities as required.

2. That utilities serving occupied portions of adjacent or surrounding facilities will not be disturbed, except as otherwise indicated.

C. If unsatisfactory conditions exist, notify the Engineer, and do not begin demotion operations until such conditions have been corrected.

3.02 PREPARATION

A. The limits of the site are shown on the Contract Drawings. The Contractor shall confine its operations within the site limits indicated.

B. Lay out cutting work at the site and coordinate with related Work for which cutting is required.

C. Review the proposed layout with the Engineer prior to performing cutting operations.

3.03 DEMOLITION

A. Operational Procedures and Methods:

1. Perform demolition and removal work in accordance with the approved Selective Demolition Plan. Perform demolition work in accordance with ANSI A10.6 and the California Code of Regulations, Title 8 and Title 24, as applicable.

2. Operational procedures shall be optional with the Contractor insofar as procedures do not infringe on the approved work schedule or salvage requirements. Conduct demolition and removal work in a manner that will minimize the spread of dust and flying particles.

3. Remove items indicated for demolition within the limits of the Work and as required to complete the Work of this Contract. Do not remove anything beyond the limits of Work indicated without prior written approval of the Engineer. If in doubt whether to remove an item, obtain written approval of the Engineer prior to proceeding.

4. Remove materials carefully, to the extent indicated and as required, providing for neat and orderly junctions between existing and new materials.

5. Protect existing structures, facilities, and landscaping from damage. Items damaged as a result of demolition operations shall be repaired or replaced, as required, at no increase in the Contract Price.

6. Perform work so as to provide the least interference and most protection to existing facilities and improvements to remain.

7. Demolish concrete and masonry in small sections. Perform demolition with small tools as much as possible. Blasting will not be permitted.

B. Jackhammering:

1. Jackhammering will be permitted only to a limited degree with prior approval of the Engineer.

2. Do not jackhammer within two inches of reinforcing or structural steel to remain. Remove final two inches of material with a chipping gun.

3.04 CUTTING

A. Cut new openings neat, as close as possible to profiles indicated.

B. Do not cut or alter structural members without the prior written approval of the Engineer.

C. Remove concrete and masonry whenever possible by saw cutting or similar approved method.

3.05 SALVAGING

A. Certain items, as indicated, shall be salvaged and reused in the Work or delivered to a District storage facility as directed.

B. Where salvaging is required, procedures shall be such that the maximum amount of salvage will result.

C. Coordinate the Work of this section closely with the Work of other sections of these Specifications requiring salvage and reuse of materials.

D. Refer to other Divisions for mechanical and electrical equipment removal and salvage requirements.

3.06 INITIAL BUILDING CLEANING

A. After demolition operations are completed, or along with demolition operations, as appropriate, clean the entire buildings and site of all dirt and dust, cobwebs, oil and grease, stains of asphalt and paint, and the various encrustations.

B. Ceilings, walls, and floors shall be dusted and wiped clean with brooms and cloths or other suitable methods as required to clean all surfaces free of dirt and dust.

C. Use suitable cleaning fluids or solvents, steel wool, blow-torch burning, scraping, and power sanding as required to remove the various encrustations and stains, including asphalt.

D. Broom clean the entire building and site immediately after demolition is complete. Provide a clean and orderly site in accordance with applicable requirements of Section 01 74 14, Cleaning.

3.07 DISPOSAL OF DEBRIS

A. Dispose of removed materials, waste, trash, and debris in a safe, acceptable manner, in accordance with applicable laws and ordinances and as prescribed by authorities having jurisdiction.

B. Burying of trash and debris on the site will not be permitted. Burning of trash and debris at the site will not be permitted.

C. Remove trash and debris from the site at frequent intervals so that their presence will not delay the progress of the work.

D. Removed materials, trash, and debris shall become the property of the Contractor and shall be removed from the District's property and disposed of in a legal manner. Location of disposal site and length of haul shall be the Contractor's responsibility.

3.08 RESTORATION OF EXISTING STRUCTURES AND FACILITIES

A. All damage to existing structures and facilities, which are to remain in place, shall be repaired to a condition equal to that existing prior to the beginning of demolition and removal operations. The cost of repairing existing structures and facilities damaged by the Contractor's operations shall be at the Contractor's expense.

3.09 FIELD QUALITY CONTROL

A. Following performance of the Work, perform an inspection of the premises and report defects and structural weaknesses of structures partially demolished, cut, or removed; of adjacent structures; and of improvements remaining.

B. The Engineer will accompany the Contractor before and after performance of the Work to confirm the physical condition of the structures and improvements involved.

END OF SECTION 02 41 19

SECTION 03 01 08

CONCRETE RESTORATION

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Cutting and chipping.

B. Repairing of cracks.

C. Restoration work.

D. Removal of paint.

1.02 MEASUREMENT AND PAYMENT

A. Measurement: Repair and restoration of existing concrete work will be measured for payment by the lump-sum method, acceptably performed and completed.

B. Payment: Repair and restoration of existing concrete work will be paid for at the indicated Contract lump-sum price as indicated in the Bid Schedule of the Bid Form.

1.03 RELATED SECTIONS

A. Coordinate the Work of this Section with the Work of other Sections specifying remedial work, corrective measures, and restoration work, including Section 01 71 23, Field Engineering, Section 01 74 14, Cleaning, and Section 02 41 19, Selective Structure Demolition.

B. Surface Preparation as specified in Section 09 91 00, Painting.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM C881/C881M — Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
2. ASTM C928/C928M — Standard Specification for Packaged, Dry Rapid-Hardening Cementitious Materials for Concrete Repairs
3. ASTM C1107/C1107M — Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)

1.05 REGULATORY REQUIREMENTS

A. In addition to the foregoing referenced standards, the regulatory requirements which govern the work of this Section include the following code requirements:

1. California Code of Regulations (CCR), Title 24, Part 10, California Existing Building Code

1.06 DESCRIPTION

A. The station or building involved in this work will be in continuous operation during the construction period. This will require that the Contractor plan the Work carefully to work around unavoidable obstacles in the prosecution of the Work. It will require further that the Contractor complete some new construction facilities required in the renovation work before proceeding with the concrete restoration work.

B. Provide such additional temporary facilities as may be required to facilitate continuous, unobstructed station or building operations during transitional construction work.

1.07 QUALITY ASSURANCE

A. Repair and restoration of existing concrete surfaces shall be performed by a skilled and experienced subcontractor specializing in the restoration of concrete with at least five years' experience in the type of work involved.

B. Repair and restoration of existing concrete work shall achieve security, strength, and weather protection, as applicable and required, and shall preserve the integrity and continuity of fire-rated assemblies.

C. Repair and restoration of existing concrete work shall successfully duplicate undisturbed adjacent finishes, colors, textures, and profiles. Where there is a dispute as to whether or not duplication is successful or has been achieved to a reasonable degree, the Engineer's judgment shall be final.

PART 2 – PRODUCTS

2.01 MATERIALS, EQUIPMENT, AND FACILITIES

A. Requirements: Provide all materials, equipment, tools, appurtenances, facilities, and services as required for performing and completing all repair and restoration of existing concrete as indicated.

B. Equipment, Tools, and Materials: Provide appropriate and proper equipment, tools, and materials for the chipping and air-pressure cleaning of cracks in concrete, for pressure injection grouting of cracks in concrete, for sandblasting or water-blasting of concrete surfaces, and for hose cleaning of concrete.

C. Concrete Bonding Agent: Adhesive for the bonding of new mortar and grout to existing concrete shall be an epoxy adhesive meeting requirement of ASTM C881/C881M, of type required for the conditions.

D. Mortar and Cementitious Repair Materials:

1. Mortar: Mortar shall be an epoxy mortar, polymer-fortified mortar, or similar high-strength bonding mortar conforming with ASTM C928/C928M. Minimum compressive strength at 28 Days shall be 4,000 psi.

2. Sand: Sand shall be a clean, washed, kiln-dried, fine sand, all passing a U.S. Standard No. 16 sieve.

E. Grout: Grout for pressure-injection grouting shall be a high-strength, nonshrink, cementitious, adhesive grout conforming with ASTM C1107/1107M, or a high-strength, nonshrink, manufactured epoxy adhesive grout. Minimum compressive strength at 28 Days shall be 5,000 psi.

F. Cleaning Agent: Mild solution of hydrochloric acid or muriatic acid, for washing of stubborn stains on concrete.

G. Paint: Paint for touchup work shall be an exterior acrylic-latex masonry paint, flat texture, color as required to match adjacent surfaces.

PART 3 – EXECUTION

3.01 REQUIREMENTS

A. Perform cutting, chipping, patching/restoring work, and cleaning in a manner to prevent damage to other work, and as required to return exterior building surfaces to essentially their original condition and configuration.

B. Major cracks shall be repaired and filled by pressure-injection grouting. All other cracks shall be repaired in the manner most appropriate and as required for weatherproofing or waterproofing the building or structure.

C. Do not cut or alter structural members when not indicated without prior approval of the Engineer.

D. Finish or refinish as required to match adjacent finishes.

3.02 CUTTING AND CHIPPING

A. Cutting and chipping work shall be neatly and accurately performed with proper tools and equipment. Cuts shall be of minimum size required for the work. Check the locations carefully of existing concrete reinforcement before cutting or chipping.

B. Pachometer readings shall be taken by the Contractor’s employed testing laboratory to locate reinforcing steel in existing concrete to be cut or chipped.

C. Existing work to remain shall be properly protected to prevent damage from cutting and chipping operations.

3.03 REPAIRING OF CRACKS

A. Cracks shall be repaired and filled with grout by the pressure-injection process. Concrete cracks shall be mapped, and the injection shall be on center-to-center spacing as necessary to achieve proper structural bonding.

B. Adhesive material shall be mixed with grout in proportion necessary to provide structural bonding of concrete. Grout material shall be inserted into cracks by pressure-injection grouting in accordance with the manufacturer's installation instructions and recommendations.

C. Minor cracks too small for injection grouting shall be repaired as specified in Article 3.04 for restoration work.

D. Small holes, cracks, and other imperfections to be painted shall be suitably primed and patched with a compound recommended by the manufacturer of the paint to be applied to these surfaces as specified in Section 09 91 00, Painting.

3.04 RESTORATION WORK

A. Preparation of Existing Surfaces: Where concrete is cracked or spalled, cut or chip out to solid surface. Use power wire brush and high pressure air to clean concrete of dirt, dust, and loose particles. Clean exposed reinforcing bars with power wire brushing to remove all visible corrosion.

B. Repairing of Concrete:

1. Repairing and patching of existing concrete work shall be expertly performed with specified adhesive, mortar, and grout materials. At completion, patched surfaces shall match adjacent existing surfaces as closely as possible.

2. Concrete bonding agent, mortar, and grout shall be applied or installed where indicated, or where otherwise required, in accordance with the manufacturer's instructions and recommendations.

3. Where necessary to build out cut, spalled, or chipped concrete surfaces, mix concrete bonding agent, mortar, and sand into a special mortar, and apply in layers as required to fill out or build up surfaces. Float, trowel, or texture surfaces to match adjacent existing surfaces.

3.05 REMOVAL OF PAINT

A. Where removal of existing paint film is required for restoration of concrete surfaces, existing painted concrete and stucco surfaces shall be sandblasted by the "wet" sandblast method to remove all such paint film. Surfaces not to be sandblasted shall be properly masked and otherwise protected to preclude any damage to these surfaces.

B. Wet sandblasted surfaces shall be thoroughly dry or dried before painting as specified in Section 09 91 00, Painting.

3.06 CLEANING

A. Where existing concrete surfaces are indicated to be cleaned or washed to remove dirt, dust, and stains, such surfaces shall be washed clean to an even and uniform effect, free of stains and blemishes. Include adjacent cornices, ledges, and masonry ornaments. Method of cleaning (e.g. high-pressure water, steam cleaning, or diluted acid cleaning) are subject to approval by the Engineer.

B. All adjacent glass areas shall be cleaned after washing of concrete surfaces.

C. Replace any glass damaged by the cleaning operations.

END OF SECTION 03 01 08

SECTION 03 05 15

PORTLAND CEMENT CONCRETE

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Portland cement.

B. Aggregates.

C. Drying shrinkage of concrete.

D. Concrete admixtures and cementitious materials.

E. Tests and analysis of materials.

F. Mix designs.

G. Batching, mixing, and transporting.

H. Inspection and Testing.

1.02 MEASUREMENT AND PAYMENT

A. Measurement: Portland cement concrete will not be measured separately for payment. It will be measured in accordance with the Sections specifying construction requiring concrete.

B. Payment: Portland cement concrete will be paid for as part of the-indicated Contract unit prices or lump-sum prices for the associated concrete work as indicated in the Bid Schedule of the Bid Form.

1.03 CLASSES OF CONCRETE

A. Classes of concrete are designated by numerical symbol indicating the minimum 28 Day compressive strength, in pounds per square inch as determined by ASTM C39/C39M, and the maximum permissible size of coarse aggregate.

B. Each class of concrete may consist of one or more mixes determined by the maximum size of aggregate, cement factor, and types of admixtures or special aggregates used.

C. Each mix within a Class shall be considered a specific type, requiring acceptance of the mix design.

D. The various classes of concrete are listed in Article 3.02, Table 1 at the end of this Section.

1.04 DEFINITIONS

A. The word “concrete” followed only by a class designation (that is, Concrete Class 3000-1-inch) indicates normal weight aggregate concrete, such as concrete having a 28 Day compressive strength of 3,000 psi, a maximum coarse aggregate size of one inch, and a minimum unit weight of 145 pounds per cubic foot (without reinforcement) at 28 Days.

B. The word “HVFAC” followed only by a class designation (that is, HVFAC 4000 – one-inch) includes normal weight aggregate high volume fly ash concrete, such as HVFAC having a 56 Day compressive strength of 4,000 psi, a maximum coarse aggregate size of one-inch, with a minimum unit weight of 145 pounds per cubic foot (without reinforcement).

C. The term “lightweight concrete” indicates lightweight structural concrete which has a maximum unit weight of 115 pounds per cubic foot at 28 Days.

D. The term “fill concrete” indicates a concrete containing sufficient cement to develop a 28 Day compressive strength of 2500 psi.

E. The term “lean concrete” indicates a concrete containing the equivalent of two 94-pound sacks of cement per cubic yard.

F. The term “mass concrete” indicates any volume of concrete with dimensions large enough to require that measures be taken to cope with the generation of heat from hydration of the cement and attendant volume change in order to minimize shrinkage and cracking.

G. The term “high volume fly ash concrete” (HVFAC) indicates concrete using a mix that replaces 40 percent or more of weight of Portland cement with specified fly ash.

H. Except for the foregoing definitions, the words and terms used in these Specifications conform to the definitions given in ACI CT.

1.05 REFERENCES

A. American Concrete Institute (ACI):

1. ACI CT — Concrete Terminology
2. ACI 117 — Specification for Tolerances for Concrete Construction and Materials
3. ACI 207.1R — Guide to Mass Concrete
4. ACI 211.1 — Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
5. ACI 211.2 — Standard Practice for Selecting Proportions for Structural Lightweight Concrete

6. ACI 301 Standard Specifications for Structural Concrete
7. ACI 304R Guide for Measuring, Mixing, Transporting, and Placing Concrete
8. ACI 304.2R Placing Concrete by Pumping Methods
9. ACI 305R Guide to Hot Weather Concreting
10. ACI 306.1 Standard Specification for Cold Weather Concreting
11. ACI 318 Building Code Requirements for Structural Concrete and Commentary

B. American Society for Testing and Materials (ASTM):

1. ASTM C31/C31M Standard Practice for Making and Curing Concrete Test Specimens in the Field
2. ASTM C33/C33M Standard Specification for Concrete Aggregates
3. ASTM C39/C39M Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
4. ASTM C40/C40M Standard Test Method for Organic Impurities in Fine Aggregates for Concrete
5. ASTM C42/C42M Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
6. ASTM C88 Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
7. ASTM C94/C94M Standard Specification for Ready-Mixed Concrete
8. ASTM C114 Standard Test Methods for Chemical Analysis of Hydraulic Cement
9. ASTM C117 Standard Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
10. ASTM C123/C123M Standard Test Method for Lightweight Particles in Aggregate
11. ASTM C127 Standard Test Method for Relative Density (Specific Gravity) and Absorption of Coarse Aggregate
12. ASTM C128 Standard Test Method for Relative Density (Specific Gravity) and Absorption of Fine Aggregate

13. ASTM C131/C131M	Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
14. ASTM C136/C136M	Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
15. ASTM C142/C142M	Standard Test Method for Clay Lumps and Friable Particles in Aggregates
16. ASTM C143/C143M	Standard Test Method for Slump of Hydraulic Cement Concrete
17. ASTM C150/C150M	Standard Specification for Portland Cement
18. ASTM C157/C157M	Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete
19. ASTM C172/C172M	Standard Practice for Sampling Freshly Mixed Concrete
20. ASTM C260	Standard Specification for Air-Entraining Admixture for Concrete
21. ASTM C330/C330M	Standard Specification for Lightweight Aggregates for Structural Concrete
22. ASTM C470/C470M	Standard Specification for Molds for Forming Concrete Test Cylinders Vertically
23. ASTM C490/C490M	Standard Practice for Use of Apparatus for the Determination of Length Change of Hardened Cement Paste, Mortar, and Concrete
24. ASTM C494/C494M	Standard Specification for Chemical Admixtures for Concrete
25. ASTM C535	Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
26. ASTM 567/C567M	Standard Test Method for Determining Density of Structural Lightweight Concrete
27. ASTM C618	Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
28. ASTM C979/C979M	Standard Specification for Pigments for Integrally Colored Concrete
29. ASTM C989	Standard Specification for Slag Cement for Use in Concrete and Mortars

30. ASTM C1017/C1017M	Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete
31. ASTM C1116/C1116M	Standard Specification for Fiber-Reinforced Concrete
32. ASTM C1399/C1399M	Standard Test Method for Obtaining Average Residual-Strength of Fiber-Reinforced Concrete
33. ASTM C1240	Standard Specification for Silica Fume Used in Cementitious Mixtures
34. ASTM C1697	Standard Specification for Blended Supplementary Cementitious Materials
35. ASTM E329	Standard Specification for Agencies Engaged in the Construction Inspection, Testing or Special Inspection

1.06 DESCRIPTION

A. Portland cement concrete shall be composed of portland cement, fine aggregate, coarse aggregate, and water, with or without admixtures as approved by the Engineer, proportioned and mixed as specified herein.

1.07 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Concrete Mix Designs: Submit mix designs as herein specified in Article 2.03. Include laboratory test reports of trial strength and shrinkage tests.

1. Submit HVFAC concrete mix designs and laboratory test reports of trial strength and shrinkage tests, including data at 56 Days, at least 10 working Days before placing concrete.

2. Mass Concrete:

   a. Submit thermal control plan in accordance with Article 2.05.

   b. Submit temperature data daily as an informational submittal.

   c. Submit a daily progress report as an informational submittal. A copy of the daily report shall available at the Jobsite.

C. Product Data: Submit manufacturer’s product data for proposed concrete admixtures.

D. Samples: Furnish and deliver samples of cement and aggregates as selected by the Engineer for testing and analysis, and additional samples to the District for

information. This requirement may be waived if certificates of compliance are furnished as specified in following Article 1.07E. and Article 2.02.

E. Affidavits/Certificates: For each shipment of materials, submit evidence of compliance with Specification requirements for cement, aggregate, and admixtures. Mill tests and manufacturers' certification of compliance with ASTM Specifications will be accepted in lieu of testing of cement and analysis of aggregates. Certificates of Compliance shall be signed by the materials manufacturer and the Contractor.

F. Batch Tickets: Submit a delivery ticket with each batch of concrete delivered to the site in accordance with the requirements of ASTM C94/C94M.

G. Quality Control Program: Submit quality program meeting requirements of Article 1.08C. herein.

H. Submit for the Engineer's approval the name, address, and telephone number of the laboratory, agency, mill, or ready-mix plant which the Contractor intends to engage to design the concrete mixes.

I. Submit for the Engineer's approval the name and qualifications of the proposed concrete technologist.

1.08 QUALITY ASSURANCE AND CONTROL

A. The Contractor shall select a qualified concrete supplier capable of meeting project requirements and the requirements of these Specifications.

B. The concrete supplier shall be certified by the National Ready Mix Concrete Association and shall hold a valid certificate of conformance for concrete production facilities.

C. In conformance with applicable requirements of Section 01 45 00, Quality Control, the Contractor shall provide a quality control plan to assure control and uniformity of materials, conformance with accepted mix designs, and prompt and proper delivery of concrete to the Jobsite in accordance with applicable requirements of ASTM C94/C94M. Include in the plan all tests the Contractor will perform to verify compliance with Specification requirements, and the independent laboratory the Contractor intends to engage to perform the tests.

1.09 ENVIRONMENTAL REQUIREMENTS

A. Hot Weather Concreting:

1. Batching, mixing, and delivering of concrete in hot weather shall conform to the applicable requirements of ACI 305R.

2. Maximum ambient temperature for placing concrete shall be 90 degrees Fahrenheit. If the ambient temperature exceeds 90 degrees Fahrenheit, the mix shall be cooled by an appropriate method approved by the Engineer, such as

icing the mixing water. Maintain uniform concrete temperature of succeeding batches placed.

B. Cold Weather Concreting:

1. Batching, mixing, and delivering of concrete in cold weather shall conform to the applicable requirements of ACI 306.1.

2. When the ambient temperature drops below 35 degrees Fahrenheit, or is expected to drop below 35 degrees Fahrenheit during placement, the temperature of the mix shall be heated by adding hot water, not exceeding 120 degrees Fahrenheit, or by steam heating the aggregates, or both. Other methods of heating aggregates will not be permitted. Steam heating the aggregates may require an adjustment in the mixing water.

3. All concrete shall be protected against freezing for at least 36 hours after placing.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Portland Cement: ASTM C150/C150M, Type II, except that Tricalcium Silicate (C3S) content must not exceed 65 percent, low alkali. Type III Portland cement may be used where high early strength concrete is a requirement as approved by the Engineer. Type III Portland cement shall not be used for the mass concrete.

B. Aggregates:

1. Coarse Aggregate: ASTM C33/C33M, clean and well graded from three-eighths inch to maximum size indicated or specified. When not specified, provide one-inch maximum size (ASTM C33, Size No. 57). Deleterious materials in aggregates shall not exceed the limits specified in ASTM C33/C33M.

2. Fine Aggregate: ASTM C33/C33M, well graded from three-eighths inch to fines, washed clean. Deleterious materials in fine aggregates shall not exceed the limits specified in ASTM C33/C33M.

3. Lightweight Aggregates: ASTM C330/C330M, well graded to maximum size indicated or specified. When not specified, provide three-fourths inch to No. 4 coarse aggregate combined with ASTM C33/C33M graded fine aggregate.

4. Aggregate for Exposed Concrete: Aggregate for concrete which will be exposed to the public shall be obtained from one source for each type of aggregate required in order to produce a uniform color.

C. Special Aggregates for Reducing Shrinkage and Creep: Cast-in-place reinforced concrete used for underground structures critical to continued main line track operations, concrete for post-tensioned cast-in-place concrete and for precast,

prestressed concrete, and for topping slabs shall be produced with special aggregates conforming to the following requirements:

1. Source of Aggregates: Aggregates shall be obtained from a selected aggregate source, known to produce aggregates complying with the specified requirements, as approved by the Engineer.

2. Coarse Aggregate:

   a. Coarse aggregate shall consist of hard, dense, durable crushed or uncrushed gravel or crushed aggregate conforming to ASTM C33/C33M and the herein specified requirements. Deleterious substances in aggregates shall not exceed the following limits:

Deleterious Material	Percent By Weight
1) Material Passing No. 200 Sieve (ASTM C117):	
a) Nominal size range No. 4 to 3/4 inch:	0.5
b) Nominal size range 3/4 inch to 1-1/2 inch:	0.4
2) Shale (ASTM C123/C123M, specific gravity of heavy liquid 1.95):	1.0
3) Clay lumps (ASTM C142/C142M):	0.5
4) Other deleterious substances:	1.0
5) Total of all deleterious substances:	3.0

   b. Coarse aggregate shall conform to the following requirements when tested in accordance with the specified ASTM Test Methods:

      1) Resistance to Abrasion (ASTM C131/C131M): The loss for aggregate size range three-fourths inch to three-sixteenths inch after 100 revolutions and 500 revolutions shall not exceed 10 percent and 40 percent, respectively. The test sample shall consist of seven parts of grading B and three parts of grading C.

      2) Resistance to Abrasion (ASTM C535): The loss for aggregate size range one-and-one-half inch to three-fourths inch (grading 3) after 200 revolutions and 1000 revolutions shall not exceed 10 percent and 40 percent, respectively.

      3) Soundness (ASTM C88): Weighted average loss after five cycles shall not exceed 12 percent when tested with sodium sulfate.

      4) Specific Gravity (ASTM C127): Bulk specific gravity on the basis of saturated surface-dry aggregate shall be not less than 2.60.

      5) Absorption (ASTM C127): Absorption shall not exceed three percent.

      6) Potential Reactivity (ASTM C33/C33M): Only aggregates considered innocuous in accordance with Appendix XI shall be used in the work.

3. Fine Aggregate:

   a. Fine aggregate shall consist of hard, dense, durable, stone or rock fragments conforming to ASTM C33/C33M and the herein specified requirements. Deleterious substances in aggregate shall not exceed the following:

Deleterious Material	Percent By Weight
1) Material passing No. 200 sieve (ASTM C117):	3.0
2) Shale (ASTM C123/C123M, specific gravity of heavy liquid 1.95):	1.0
3) Clay lumps (ASTM C142/C142M):	1.0
4) Total of other deleterious substances, (such as alkali, mica, coated grains, soft flaky particles, and loam):	2.0
5) Total of all deleterious substances:	5.0

   b. Fine aggregate shall conform to the following requirements when tested in accordance with the specified ASTM Test Methods:

      1) Specific Gravity (ASTM C128): Not less than 2.60 on a saturated surface-dry basis.

      2) Organic Impurities (ASTM C40/C40M): Supernatant liquid must be lighter in color than the reference standard color solution.

      3) Soundness (ASTM C88): Loss in five cycles of sodium sulfate test shall not exceed 12 percent.

      4) Fineness Modulus (ASTM C33/C33M): Fineness modulus shall be in the range of 2.30 to 3.00, however, the variation of the fineness modulus shall not exceed 0.20.

D. Concrete Admixtures and Cementitious Materials: The Contractor may include accepted concrete admixtures and cementitious materials in the mix to improve the water-cement ratio or water-cementitious ratio or workability of the concrete, providing the strengths specified and other desirable characteristics of the concrete can be achieved and maintained. Admixtures require the Engineer's acceptance before they may be used, and shall be included in the design mix, introduced in solution form. Admixtures shall be added at the batch plant, except as otherwise noted herein.

   1. Chemical Admixtures, Water-Reducing: ASTM C494/C494M, Type A.

   2. Air Entraining Admixtures: ASTM C260

   3. Pozzolanic Admixtures: ASTM C618, Class N or F.

   4. Fly Ash: ASTM C618, Class F, with a maximum of 25 percent retained on the No. 325 mesh sieve and a loss on ignition of 1.0 percent maximum.

5. Pigments for integrally colored concrete: ASTM C979/C979M, for synthetic or natural iron oxides (red).

6. Chemical Admixtures, Plasticizing: ASTM C1017/C1071M, or ASTM C494/C494M Type F or Type G, high-range water-reducing admixtures.

7. Prohibited Admixtures: Admixtures containing chlorides or sulfides are not acceptable.

8. Slag Cement (GGBFS): Cementitious material conforming to ASTM C989/C989M.

9. Silica Fume: Cementitious material conforming to ASTM C1240.

10. Blended supplementary cementitious material conforming to ASTM C1697 except Fly Ash shall be as specified hereinabove. The amount of each cementitious material in the blend will be used separately in calculating the mix design equation specified herein Article 2.03.

E. Water: Water for concrete mixes, curing, and cleaning shall be clean and potable, free of impurities detrimental to concrete.

F. Reinforcement Fibers: Chopped strands of alkali-resistant polypropylene fibers added to the concrete mix for protection against shrinkage cracks where indicated or required. Reinforcement fibers shall be minimum of 2 inches in length and have an aspect ratio of 50 to 90. The fiber shall have a minimum average residual strength of 200 psi when measured in accordance with ASTM C1399/C1399M.

2.02 TESTS AND ANALYSES OF MATERIALS

A. Tests and Sample Analyses: Testing of cement and analysis of aggregates shall be performed by the Contractor as specified herein. Mill tests and supplier's certification of compliance with ASTM Specifications will be accepted in lieu of testing of cement and analysis of aggregates. Tests and services shall consist of the following:

1. Testing of Portland cement in accordance with ASTM C150/C150M and ASTM C114.

2. Analysis of aggregates in accordance with ASTM C33/C33M, and sieve analysis of fine and coarse aggregates in accordance with ASTM C136/C136M.

3. Tests of special aggregates for reducing shrinkage and creep shall conform to the requirements herein specified under Article 2.01C.

B. Samples: Furnish and deliver identified samples of materials required for tests and analysis in the amounts required by the Contractor's employed independent testing laboratory without charge. Samples shall be selected at random by the testing

laboratory. Deliver samples of cement and aggregates at least 30 Days prior to use on the project.

2.03 MIX DESIGNS

A. Design of concrete mixes, including recommended amounts of admixture and water to be used in the mixes, shall be obtained by the Contractor from a qualified independent testing laboratory or agency, or from a mill or ready-mix plant, properly equipped to design concrete mixes. The design shall be performed and certified by a professional engineer currently registered as a civil or structural engineer in the State of California. The laboratory, agency, mill, or ready-mix plant shall meet applicable requirements of ASTM E329, and shall be approved by the Engineer. Costs of obtaining the mix designs shall be paid by the Contractor.

1. In addition to the requirements specified above, concrete mix designs for HVFAC shall be performed by a concrete technologist with documented experience in the design of HVFAC.

B. Selection of mix proportions shall conform to the applicable requirements of ACI 211.1 and ACI 211.2. Concrete shall comply with ACI 301 and ACI 318, as applicable. Mix designs shall produce concrete suited for proper placement and finishing. Mix design shall satisfy the following equation:

$F/25 + SL/50 + UF/12 \geq 1$ where:

F = Fly Ash or Pozzolanic Admixtures specified herein Article 2.01 as a percent by weight of the total cement in the concrete

SL = Slag Cement (GGBFS) specified herein Article 2.01 as a percent by weight of the total cement in the concrete.

UF = Silica Fume specified herein Article 2.01 as a percent by weight of the total cement in the concrete.

C. Mix design for HVFAC shall include replacement of 40 to 50 percent of Portland cement by weight with Fly Ash.

D. In addition to satisfy the mix design equation specified hereinabove, mix design for subway structures and below grade retaining walls for stations and other facilities shall include a minimum of 15 percent of Fly Ash by weight of the total cement in the concrete, along with a plasticizing admixture conforming to ASTM C1017/C1071M, to provide a dense and plastic concrete with low shrinkage and permeability characteristics.

E. In addition to satisfy the mix design equation specified hereinabove, mix design for architectural concrete and formed concrete which will be exposed to the public in finished work shall include a minimum of 10 percent of Fly Ash by weight of the total cement in the concrete, along with a plasticizing admixture, conforming to ASTM

C1017/C1071M, to provide a dense and plastic concrete mix which completely fills out the forms and form detail without air holes and rock pockets.

F. Mix designs shall indicate brands, types, and quantities of admixtures included. The mix designs shall identify the percentage of each of the cementitious admixtures by weight of the total cement in the concrete and the locations in the structures where such mixes are proposed for use.

G. Mix designs for integrally colored concrete shall indicate brand type of natural or synthetic metallic oxide or pigment, and quantity used, all prepared as specified in ASTM C979/C979M. Compensate for Fly Ash with additional pigment as applicable. Concrete encasements of below-grade electrical conduits and ductbanks containing circuits over 600 Volts shall be integrally colored red concrete.

H. Mix design for mass concrete shall have a percentage of Fly Ash replacement of cement by weight to reduce the amount of heat generated during heat of hydration. Amount of fly ash to be introduced into the mix shall be approved by the Engineer. ASTM C494/C494M Type F or Type G high-range water-reducing admixture may also be used to reduce heat of hydration.

I. If concrete is to be placed by pumping, concrete mixes shall be designed in accordance with the applicable requirements of ACI 304R and ACI 304.2R, and shall include strengths and slumps.

J. Mix design shall be proportioned to meet the following slump limitations.

1. Concrete without high-range water-reducing admixture: 4 inches nominal slump

2. Concrete with high-range water-reducing admixture: Concrete nominal slump prior to addition of water-reducing admixture shall not be 3 inches for normal weight concrete. After addition of water-reducing admixture, the concrete shall be a maximum slump of 8 inches unless otherwise by Engineer.

K. Drying Shrinkage of Concrete: Cast-in-place concrete, precast concrete and prestressed concrete shall meet the following requirements:

1. A trail batch of the proposed (mix design) concrete shall be prepared using the aggregates, cement, and admixture prosed for this work. From the trial batch, three specimens (four inches by four inches by 11 inches) for determining “Drying Shrinkage” shall be prepared, cured, dried, and measured as specified in ASTM C157/C157M and ASTM C490/C490M, with the following modifications:

   a. Cast-in-place concrete shall be moist cured for 10 Days.

   b. Precast, prestressed concrete shall be steamed cured one Day.

   c. Measurements shall be made and reported for seven, 14, 21, and 28 Days of drying after nine Days of moist curing and one Day of steam curing. Measurements for HFVAC shall also be made and reported for 56 Days of drying.

2. Shrinkage of specimens for cast-in-place concrete shall not exceed 0.040 percent when measured in accordance with ASTM C157/C157M and ASTM C490/C490M after 21 Days of drying.

3. Shrinkage of specimens for precast and prestressed concrete shall not exceed 0.035 percent when measured in accordance with ASTM C157/C157M and ASTM C490/C490M after 21 Days of drying.

4. Shrinkage of HVFAC specimens shall not exceed 0.055 percent when measured in accordance with ASTM C157/C157M after 28 Days drying including minimum seven Days moist cure.

L. Mix designs shall indicate location of each mix within the structure. Mix designs shall specify both coarse and fine aggregate sources.

M. Upon receipt of acceptable mix designs from the prequalified testing laboratory or agency or concrete supplier, conforming to specified requirements, the Contractor shall submit these accepted mix designs to the Engineer for review, 10 Days prior to batching or delivering any concrete.

N. Concrete mixes shall contain the minimum number of 94-pound sacks of cement per cubic yard specified in Article 3.02, Table 1, regardless of the fact that the strengths specified may be obtained with lesser amounts of cement. Exception will be made only for mass concrete to reduce heat of hydration as hereinbefore specified.

O. The water-to-cement ratio shall not exceed 0.4 for concrete used for underground structures critical to main line track operations that may be exposed to underground water. The water-cement ratio shall not exceed 0.45 for above ground concrete structures supporting main line track operations including but not limited to aerial structures and foundation, abutments and retaining walls, and underground structures critical to main line track operations that will not exposed to underground water. Conversion to equivalent water-to-cementitious ratio shall be performed in accordance with applicable requirements of ACI 211.1.

P. Concrete for duct banks shall have a 28 Day compressive strength of 3,000 psi, minimum.

2.04 BATCHING, MIXING, AND TRANSPORTING

A. Batching, mixing, and transporting portland-cement concrete shall conform to the applicable requirements of ACI 301 and ACI 304R.

B. Concrete shall be central-mixed concrete from a central batch plant, to be transported to the Jobsite in a truck mixer, in accordance with the requirements of ASTM C94/C94M. Equipment used in the manufacture of concrete shall be kept clean at all times.

C. Mixers shall be equipped with automatic device for recording number of revolutions of drum prior to completion of mixing operation. Each transit mixer shall also be

equipped with water measuring devices consisting of either accurately calibrated water tanks or water meters.

D. Concrete in truck mixer shall be mixed continuously until discharged. The discharge time for concrete after the introduction of mixing water shall not exceed 60 minutes. Discharge of concrete shall be completed within 90 minutes or before 250 revolutions of the drum or blades, whichever occurs first, after the introduction of the cement to the aggregates. Delivery tickets shall show departure time from plants.

E. Ready-mixed concrete shall be mixed for a period of not less than 10 minutes and at least three minutes of the mixing period shall be immediately prior to discharging at the job. The introduction of additional water into transit type mixers after leaving the plant will not be permitted.

1. If adjustment of HVFAC slump in field is necessary, it may be made by addition of high range water reducing admixture within the limitations prescribed by the concrete technologist.

2.05 MASS CONCRETE

A. Provide a thermal control plan for each mass concrete element. The thermal control plan and the calculations shall be sealed and signed by a Professional Civil or Structural Engineer registered in the State of California. Include the following:

1. Mix design.

2. Duration and method of curing.

3. Procedure to control concrete temperature differential at time of placement.

4. Method of controlling temperature differentials.

5. Temperature differential monitoring and recording system details as specified herein, Article 3.01 E.

6. Temperature sensor types and locations.

7. Measures to ensure compliance with maximum temperature and temperature differential requirements.

8. A calculation of maximum allowable temperature differential between the hottest point of the concrete and the exterior faces, assuming cracking due to heat of hydration does not occur.

9. Provide a modified thermal control plan, including supporting calculations, to correct deficiencies for replacement mass concrete.

B. Maximum Temperature and Temperature Differential

1. Maximum allowable temperature shall not exceed 160 degree Fahrenheit.

2. Maximum temperature differential must not exceed that determined by the Contractor's calculations and listed in the thermal control plan.

PART 3 – EXECUTION

3.01 FIELD QUALITY CONTROL

A. Inspection and Testing Services:

1. Visual inspections and acceptance of concrete mix designs will be by the Engineer. The Engineer will observe concrete batching, mixing, and placing operations, and the Contractor shall keep records of all concrete placed. Copies of such records shall be submitted to the Engineer for record purposes.

2. Testing services for the Contractor's quality control program, including concrete strength tests, shall be provided by an independent testing laboratory or agency, employed by the Contractor and approved by the Engineer, and shall be performed in accordance with the applicable requirements of ACI 301. If, as a result of these tests, it is determined that the specified concrete properties are not being obtained, the Engineer will order such changes in proportions or materials, or both, as may be necessary to secure the specified properties.

    a. Field tests shall be performed by personnel having ACI Level 1 Field Technician Certification.

3. Failure of the Engineer to detect defective work or material shall not prevent later rejection when such defect is discovered, nor shall it obligate the Engineer for final acceptance.

4. Additional inspection and testing services required by the Engineer because of changes in materials, sources, or proportions; or occasioned by failure of inspections and tests to meet specification requirements, shall be paid for by the Contractor.

5. Provide materials, labor, and services for sampling and testing of concrete, including the following facilities and services:

    a. Preparation, handling, storage, and delivery of concrete test specimens.

    b. Suitable containers for the storage, curing, and delivery of concrete test specimens in accordance with ASTM C31/C31M and ASTM C470/C470M.

    c. Suitable storage for a supply of test cylinder molds, test specimens to be cured at the Jobsite, and other items required for sampling and testing.

B. Methods of Sampling and Testing:

1. Sampling: Representative composite samples shall be taken by the Contractor in accordance with ASTM C172/C172M. Each sample shall be obtained from a different batch of concrete on a random basis.

2. Slump Tests: The above-specified Contractor-employed testing laboratory shall perform slump tests of concrete during placing of concrete, as required, in accordance with ASTM C143/C143M. At least one test shall be performed at the delivery trucks for each 50 cubic yards of concrete delivered.

3. Tests for Concrete Uniformity: The same testing laboratory shall perform tests for concrete uniformity in accordance with ASTM C94/C94M, Annex A1. Each batch of concrete shall be tested as specified in ASTM C94/C94M, Annex A1.

4. Tests for Concrete Temperature: Freshly mixed concrete shall be tested hourly when the ambient temperature is below 40 degrees Fahrenheit and above 80 degrees Fahrenheit, and each time compression test cylinders are made. The concrete temperature shall be recorded on all compression test cylinders made. Refer to Article 1.07 herein for hot and cold weather remedial requirements.

5. Strength Tests:

    a. The Contractor shall prepare, cast, and deliver to the same independent testing laboratory, cylinders for laboratory-cured compression test samples. Cylinders shall be made and cured in accordance with ASTM C31/C31M. Cylinders shall be tested in accordance with ASTM C39/C39M.

    b. The minimum number of test cylinders to be made for each class of concrete and for each placement shall be four cylinders for each 100 cubic yards or fraction thereof. When additional sets of test cylinders are required beyond the normal seven and 28 Day tests, each set shall consist of a minimum of two test cylinders.

    c. All cylinders in a set shall be marked with a unique number on one end. The Contractor shall record this number on the record of concrete placed. All cylinders shall be cured by the Contractor's independent testing laboratory.

    d. From each set of cylinders cast, one cylinder shall be tested at seven Days and two cylinders at 28 Days in accordance with ASTM C39/C39M. If the 28 Day tests are satisfactory, the fourth cylinder shall be discarded.

    e. In the event the 28 Day tests are below the specified strength requirements, the Laboratory shall then test the fourth cylinder at the age selected by the Engineer.

6. Strength Tests for HVFAC: In additional to the strength test requirements specified above the following provisions apply to HVFAC:

    a. The minimum number of test cylinder to be made for HVFAC for each class and for each placement shall be six laboratory cured cylinders for each 100 cubic yards or fraction thereof.

    b. When the ambient air temperature at time of placement of HVFAC is less than 50 degrees Fahrenheit, four additional cylinders shall be taken hourly and tested.

    c. From each set of HVFAC laboratory cured cylinders cast, two each shall be tested at seven, 28, and 56 Days.

7. Tests for Contractor's Benefit: Tests required verifying early form removal, or other reasons for the Contractor's benefit, shall be performed at Contractor's expense as part of the Contractor's quality control program.

C. Evaluation and Acceptance of Tests:

1. Acceptance of Concrete: The strength of the concrete shall be considered satisfactory, provided the averages of all sets of three consecutive strength test results equal or exceed the specified 28 Day compressive strength, and no individual strength test result falls below the specified 28 Day compressive strength by more than 500 psi.

    a. Acceptance of HVFAC: The strength of HVFAC shall be considered satisfactory, provided the averages of all sets of three consecutive strength test results equal or exceed the specified 56 Day compressive strength, and no individual strength test result falls below the specified 56 Day compressive strength by more than 500 psi.

2. Adjustments: The Contractor's independent testing laboratory shall order adjustments to the mix proportions, increase in the minimum cement content, additional curing of the structure, or any combination of the above when strength tests acceptance criteria specified are not being met.

3. Test Cores:

    a. When laboratory test results indicate concrete to be more than 300 psi below the specified strength, or if there is a likelihood of low strength concrete, a significant reduction in load-carrying capacity, or absence of desired durability in the concrete, the Engineer will require tests of cores to be drilled from the areas in question.

    b. Test cores shall be obtained from each member or area of suspect strength, from locations designated by the Engineer, and test specimens shall be prepared by the Contractor in accordance with ASTM C42/C42M.

    c. Three cores shall be taken for each determination of in-place strength. Concrete in the area represented by the core tests will be considered structurally adequate if the average of the three cores is equal to at least 85 percent of the specified design strength and no single core is less than 75 percent of the design strength. Locations represented by erratic core strengths shall be retested at the direction of the Engineer.

    d. Fill core holes in accordance with the requirements of Section 03 35 00, Concrete Finishing, for repair of surface defects.

4. Rejection of Concrete; Repair and Replacement: The Engineer has authority to reject concrete work which does not meet specification requirements, and to require repair or replacement as necessary to complete the Work.

D. Acceptance of Structure: Acceptance of the completed concrete work requires conformance with the dimensional tolerances, appearance, and strengths specified in these Specifications, in ACI 301, and in ACI 117.

E. Temperature Monitoring for Mass Concrete

1. Provide a temperature monitoring and recording system for mass concrete elements. The system must consist of temperature sensors connected to a data acquisition system. The system must be capable of recording, printing, and downloading temperature data to a computer.

2. Locate temperature sensors within the mass concrete elements such that the maximum temperature differential within the element is monitored. At a minimum, monitor temperatures at the following locations:

    a. Calculated hottest location

    b. Two outer faces

    c. Two corners

    d. Top surfaces

3. Record temperature reading automatically at least every hour. Install a redundant set of sensors near the primary set with recording capability. Make records using the redundant set if the primary set fails.

4. Hourly temperature recording may be discontinued as approved by the Engineer under the following conditions:

    a. Maximum internal temperature is falling.

    b. Differential between the interior concrete temperature and the average daily air temperature is less than the allowable temperature differential for three consecutive days.

5. Protect temperature sensor wiring to prevent movement during concrete placement. Keep wire runs as short as possible. The ends of temperature sensors shall not be in contact with concrete supports, forms, or reinforcement.

6. Do not damage the monitoring and recording system when placing and consolidating concrete.

7. Correct equipment failures in temperature control, monitoring, and recording systems immediately.

3.02 SCHEDULES

Table 1: PORTLAND CEMENT CONCRETE MIXES

CLASSIFICATION		MINIMUM CEMENT CONTENT
Compressive Strength (psi Classification)	**Maximum Aggregate Size**	**94-Pound Sacks per cubic yard**
Reinforced Concrete (psi Classification at 28 Days)		
2500	3/8 inch	5.0
2500	1 inch	4.5
2500	1-1/2 inch	4.5
3000	3/8 inch	5.5
3000	1 inch	5.0
3000	1-1/2 inch	5.0
3500	3/8 inch	6.0
3500	1 inch	5.5
3500	1-1/2 inch	5.0
4000	3/8 inch	6.5
4000	1 inch	6.0
4000	1-1/2 inch	5.5
4500	3/8 inch	7.0
4500	1 inch	6.5
4500	1-1/2 inch	6.0
5000	3/8 inch	7.0
5000	1 inch	6.5

Table 1: PORTLAND CEMENT CONCRETE MIXES

CLASSIFICATION		MINIMUM CEMENT CONTENT
Compressive Strength (psi Classification)	**Maximum Aggregate Size**	**94-Pound Sacks per cubic yard**
Prestressed Concrete (psi Classification at 28 Days)		
5000	1 inch	7.0
6000	1 inch	7.5
High Volume Fly Ash Concrete (psi Classification at 56 Days)		
4000[i]	1 inch	See Notes[ii]
4000	1-1/2 inch	See Notes[ii]

END OF SECTION 03 05 15

[i] Compressive Strength at seven Days shall be 2,000 psi, at 28 Days 4,000 psi.
[ii] Cement content and maximum water to cementitious material ratio in accordance with the recommendations of the concrete technologist as approved by the Engineer.

SECTION 03 05 18

PRESTRESSED CONCRETE

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Prestressing tendons, anchors, coatings, sheathing, couplings, sleeves and gaskets.

B. Concrete and grout.

1.02 RELATED SECTIONS

A. Concrete formwork is specified in Section 03 11 00, Concrete Forming.

B. Concrete falsework is specified in Section 03 11 14, Falsework.

C. Reinforcing steel for concrete (typical rebar) is specified in Section 03 20 00, Concrete Reinforcing.

D. Cast in place concrete is specified in Section 03 30 00, Cast In Place Concrete.

E. Portland cement concrete is specified in Section 03 05 15, Portland Cement Concrete.

F. Finishing and curing of concrete are specified in Section 03 35 00, Concrete Finishing, except as modified herein for precast, prestressed concrete.

G. Requirements for precast concrete are specified in Section 03 40 00, Precast Concrete.

1.03 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for prestressed concrete will be either by the lump-sum method or by the unit-price method as determined by the listing of the bid item for prestressed concrete indicated in the Bid Schedule of the Bid Form.

B. Lump Sum: If the Bid Schedule indicates a lump sum for prestressed concrete, the lump-sum method of measurement and payment will be in accordance with Section 01 20 00, Price and Payment Procedures, Article 1.03.

C. Unit Price

1. If the Bid Schedule indicates a unit price for prestressed concrete, the unit-price method of measurement and payment will be as follows:

a. Measurement:

1) Cast-in-Place, Post-Tensioned, Prestressed Concrete: Concrete for prestressed concrete will be measured for payment by the cubic yard, as

specified in Section 03 30 00, Cast-In-Place Concrete, and will include prestressing steel tendons, sheathing and ducts, distribution plates, anchorage devices, grout, reinforcing steel, embedded items, and prestressing operations, as applicable.

2) Precast/Prestressed Concrete: Precast, prestressed concrete members will be measured for payment by the individual unit (each), erected and installed in place, multiplied by the total number of identical units installed, and will include prestressing steel tendons, sheathing ducts, distribution plates, anchorage devices, grout, reinforcing steel, embedded items, and prestressing operations, as applicable.

b. Payment: Prestressed concrete will be paid for at the indicated Contract unit prices for the computed quantities as determined by the measurement method specified in Article 1.03.C.1.a.

1.04 REFERENCES

A. American Concrete Institute (ACI):

1. ACI 301 Specifications for Structural Concrete

2. ACI 318 Building Code Requirements for Structural Concrete and Commentary

B. Precast/Prestressed Concrete Institute (PCI):

1. PCI MNL 116 – Manual for Quality Control for Plants and Production of Structural Precast Concrete Products

2. PCI Design Handbook – Precast and Prestressed Concrete

C. Post-Tensioning Institute (PTI):

1. Post-Tensioning Manual

1.05 DEFINITIONS

A. The words and terms used in these Specifications conform to the definitions given in ACI 301 and ACI 318.

1.06 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Comply with requirements of ACI 301, Section 9 – Post-tensioned Concrete.

C. Preliminary Data: Comply with requirements of ACI 301 Section 9 – Post-tensioned Concrete.

D. Field Data: Comply with requirements of ACI 301, Section 9 – Post-tensioned Concrete.

E. Installer Certification: Comply with requirements specified herein Article 3.05.

1.07 QUALITY ASSURANCE

A. Governing Standards:

1. American Concrete Institute: ACI 301 in its entirety is hereby incorporated into these Specifications. ACI 301, Section 9 – Post-tensioned Concrete except Contractor shall provide testing services in accordance with Contract Specifications Section 01 45 00, Quality Control, and ACI 318, Chapters 4, 19, and 26, shall govern the work of this Section, as applicable.

2. Precast/Prestressed Concrete Institute: Comply with the herein referenced PCI Manual 116 and the PCI Design Handbook – Precast and Prestressed Concrete, as applicable.

3. Post-Tensioning Institute: Comply with the herein referenced PTI Post-Tensioning Manual, as applicable.

B. Testing: Comply with ACI 301, Section 9 – Post-tensioned Concrete, for the following test requirements:

1. Anchorage test assembly;

2. Static test;

3. Fatigue and hydrostatic tests for unbonded tendons; and

4. Grout quality control testing.

C. Tolerances: Comply with requirements of ACI 301, Section 9 – Post-tensioned Concrete.

D. Precast, Prestressed Concrete: Comply with requirements of Section 03 40 00, Precast Concrete, as applicable to the precast and erection portions of the work.

1.08 PRODUCT DELIVERY, HANDLING, AND STORAGE

A. Comply with requirements of ACI 301, Section 9 – Post-tensioned Concrete.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Provide materials that comply with ACI 301, Section 9 – Post-tensioned Concrete, for the following:

1. Prestressing steel;
2. Ducts for tendons;
3. Coatings for unbonded tendons;
4. Sheathing for bonded tendons;
5. Sheathing for unbonded tendons;
6. Anchorages for bonded tendons;
7. Anchorages for unbonded tendons;
8. Couplings; and
9. Sleeves and caps.

2.02 DESIGN OF CONCRETE AND GROUT MIXTURES

A. Concrete: Comply with requirements of Section 03 05 15, Portland Cement Concrete. Provide Class 6000 concrete unless otherwise indicated. Proportion concrete mixtures in accordance with ACI 301, Section 4 – Concrete Mixtures except the water-to-cement ratio shall not exceed the requirements specified in Section 03 05 15, Portland Cement Concrete.

B. Grout: Comply with requirements of ACI 301, Section 9 – Post-tensioned Concrete.

PART 3 – EXECUTION

3.01 INSPECTION

A. Comply with requirements of ACI 301, Section 9 – Post-tensioned Concrete.

3.02 PREPARATION

A. Comply with requirements of ACI 301, Section 9 – Post-tensioned Concrete, for the following:

1. Tendon installation; and
2. Grouting.

3.03 CONCRETE PLACEMENT

A. Comply with requirements of ACI 301, Section 9 – Post-tensioned Concrete, for the following:

1. Tendons and accessories; and

2. Non-prestressed reinforcement.

3.04 TENSIONING AND OTHER OPERATIONS INVOLVING TENDONS

A. Comply with requirements of ACI 301, Section 9 – Post-tensioned Concrete, for the following:

1. Sequence;

2. Tensioning multiple-strand tendons;

3. Prestressing force;

4. Prestress loss;

5. Formwork;

6. Prevention of damage to tendons, and

7. Tendon finishing.

3.05 INSTALLER CERTIFICATION

A. Installation shall be performed by personnel in accordance with requirements of ACI 301, Section 9 – Post-tensioned Concrete, Submit the qualifications of the installation personnel to the Engineer for approval two weeks before installation.

END OF SECTION 03 05 18

SECTION 03 11 00

CONCRETE FORMING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Layout of formwork.

B. Formwork construction.

C. Embedded items and openings in concrete.

D. Form release materials.

E. Removal of forms.

F. Field quality control.

G. Detection of movement.

H. Re-use of forms.

1.02 RELATED SECTIONS

A. Falsework for concrete structures is specified in Section 03 11 14, Falsework. Coordinate formwork supported by falsework with the requirements of Section 03 11 14.

B. Finishes for formed surfaces are specified in Section 03 35 00, Concrete Finishing.

C. Concrete mix design as specified in Section 03 05 15, Portland Cement Concrete.

D. Waterstops as specified in Section 03 15 13, Waterstops.

E. Installation of AC plug as specified in Section 32 11 17, Aggregate Subbase, Section 32 11 23, Aggregate Base Course, and Section 32 12 16, Asphalt Paving.

1.03 MEASUREMENT AND PAYMENT

A. Measurement: Concrete formwork will not be measured separately for payment.

B. Payment: Concrete formwork will be paid for as part of the indicated Contract unit price or lump-sum price for the associated cast-in-place concrete work as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. American Concrete Institute (ACI):

1. ACI 117 Specification for Tolerances for Concrete Construction and Materials and Commentary
2. ACI 301 Specifications for Structural Concrete
3. ACI 318 Building Code Requirements for Structural Concrete and Commentary
4. ACI 347R Guide to Formwork for Concrete

B. American Plywood Association (APA):

1. U.S. Product Standard PS-1 Structural Plywood

C. West Coast Lumber Inspection Bureau (WCLIB):

1. WCLIB Standard No. 17 Grading Rules for West Coast Lumber

1.05 QUALITY ASSURANCE

A. Formwork Standards: Unless otherwise indicated, design, construct, erect, maintain, and remove forms and related structures for concrete work in accordance with applicable requirements of ACI 301, ACI 318, and ACI 347R.

1. Architectural Concrete: Forms for architectural concrete shall be designed and constructed in accordance with ACI 301.
2. Deflection: Where dead and live loads on forms will be more than 20 percent greater than the weight of the concrete, provide framing lumber of required strength, and comply with ACI 301 and ACI 347R for design of framing members. Deflection shall be kept within the herein specified tolerances.
3. Concrete Mix Design: Design of formwork shall be coordinated with the concrete mix design, as specified in Section 03 05 15, Portland Cement Concrete, so that form materials, form surfaces, and formwork strength will produce the desired concrete tolerances and finishes.

B. Formwork Surface Materials: Provide material and work quality which will produce clean and uniform finished surfaces within the allowable tolerances specified and which will conform with the following requirements:

1. Concrete Exposed to View: Provide material and work quality that will produce clean, smooth, and uniform concrete surfaces. Refer to Section 03 35 00, Concrete Finishing, and ACI 301 for requirements.
2. Concrete Concealed from View: Provide material and work quality that will produce aligned concrete surfaces free of fins, honeycomb, and stains.

C. Special Formwork Sections: Provide openings, offsets, sinkages, keyways, recesses, moldings, rustication strips, chamfers, blocking, screeds, bulkheads, anchorages, embedded items, and other features. Select materials and provide workmanship that will ensure indicated finishes.

D. Chamfered Corners: All external corners shall be chamfered, unless otherwise indicated.

E. Removal Features: Design formwork to be readily removable without impact, shock, and damage to concrete surfaces and adjacent materials.

F. Tolerances for Formed Surfaces: For buildings and similar structures, comply with the requirements of ACI 301, as applicable. For those items of work or parts of the structure not covered by ACI 301, comply with the requirements of ACI 117, as applicable. Coordinate with the requirements specified in Section 03 30 00, Cast-In-Place Concrete.

1. The class of surface for offset between adjacent pieces of formwork facing material shall be Class A for surfaces permanently exposed to public view and Class C for surfaces that will be permanently concealed, unless otherwise specified.

G. Abrupt and Gradual Irregularities Tolerances for Formed Surfaces: In addition to the tolerance requirements of ACI 301, surfaces of buildings and similar structures permanently exposed to view shall conform to the abrupt and gradual irregularities tolerances specified herein. Abrupt irregularities shall be understood to mean offsets and fins resulting from displaced, mismatched, or misplaced forms, sheathing, or liners or from defects in forming materials are considered abrupt irregularities. Gradual irregularities shall be understood to mean those resulting from warping and similar uniform variations from planeness or true curvature. Gradual irregularities shall be checked with a straightedge for plane surfaces or a shaped template for curved or warped surfaces.

1. In measuring irregularities, the straightedge or template shall be placed in various places on the surface in various directions. Permitted abrupt or gradual irregularities in formed surfaces as measured within a five-foot length with a straightedge shall be as specified in ACI 117, Section 4.8.3, Formed Surface Irregularities (gradual or abrupt):

Class of Surface	Maximum Abrupt or Gradual Irregularity
A	One eighth inch
B	One fourth inch
C	One half inch
D	One inch

1.06 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures. For formwork submittals involving shoring or falsework, comply with requirements specified in Section 03 11 14, Falsework.

B. Shop Drawings: Submit drawings that indicate and include the following details and requirements:

1. Forming system and method of erection with associated details.

2. Shoring accompanied by design calculations. Include reshoring procedures. Both drawings and calculations shall be signed by an engineer who is currently registered as a civil or structural engineer in the State of California. Coordinate with Section 03 11 14, Falsework.

3. Locations of construction joints in plan and elevation views. Means of leakage prevention for concrete exposed to view in finished construction.

4. Locations and sizes of conduits, openings, recesses, pipes, ducts, and other attached or embedded products.

5. Beam intersections and other conditions where concrete casting by vertical drop may be restricted.

6. Chamfer strips for corner treatment.

7. Method and schedule for removing forms and shoring.

8. Method for detecting formwork movement during concrete placement.

C. Product Data: Submit manufacturers' product data for manufactured products. Include products proposed for leakage control.

D. Samples: Submit form material, 12 inches by 12 inches or larger in size, for formed concrete which will be exposed in the finished work to public view. Such samples require approval of the Engineer before they may be used in the work.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Storage: Store form panels to prevent warpage. Protect panels from damage and contamination which could adversely affect concrete.

B. Handling: Lift form panels by methods that will protect panels from damage and distortion.

1.08 JOB CONDITIONS

A. Allow sufficient time between erection of forms and placing of concrete for the various trades to properly install concrete reinforcement, embedded items, sleeves, and blockouts.

B. Do not apply superimposed loads to the structure until concrete has developed its specified 28-day compressive strength.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Lumber: Boards and framing lumber shall be graded and grade-marked in accordance with WCLIB Standard No. 17. Provide framing lumber of required strength, conforming with the above-specified WCLIB Standard No. 17.

1. Boards: Provide all West Coast Species, “Construction” or “Standard” Boards. Use dressed side of lumber for surface in contact with the concrete, and provide boards with dressed or tongue-and-groove edges to provide tight joints to prevent mortar leakage.

2. Framing Lumber:

   a. Light Framing: Provide all West Coast Species, “Construction” or “Standard” Light Framing, dressed or rough. Where loads are not a factor, “Utility” Light Framing will be acceptable.

   b. Joists and Planks: Provide all West Coast Species, “No. 2” Structural Joists and Planks, dressed or rough.

   c. Beams and Stringers: Provide all West Coast Species, “Standard” Beams and Stringers or “No. 2 Structural” Beams and Stringers, dressed or rough.

B. Plywood (Plyform): Plywood shall be graded and grade-marked in accordance with U.S. Product Standard PS-1.

1. B-B Plyform: Provide Class I, EXT-APA, mill-oiled, edge-sealed, APA trade marked.

2. B-C Plyform: Provide Class I, EXT-APA, APA trade marked.

3. High Density Overlay (HDO) Plyform: Provide A-A, 60-60, Class I, EXT-APA, APA trade marked.

4. Thickness: As required to maintain surface smoothness without deflection, but not thinner than 5/8 inch.

C. Steel Forms: Proprietary, patented, or fabricated steel forms, using standard or commercial quality, uncoated steel sheet or plate, 3/16-inch minimum thickness, for panel facings. Provide surfaces that will not impart corrosion residue to concrete. Include panel framing, reinforcement, and erection accessories.

D. Waffle Slab Forms: Steel or reinforced plastic dome forms for two-way joist construction, smooth surface, of sizes indicated.

E. Round Column Forms: Pressed or molded fiber-reinforced plastic or steel, manufactured round column forms, seamless or one-piece (one vertical seam), smooth surface, of sizes indicated.

1. Provide forms with will not deflect under pressure of concrete placement, and which will not deflect or blow off under added pressure of placement of fly-ash-modified concrete.

F. Formliners for Exposed and Architectural Concrete: Thermally formed, pressed or molded fiber-reinforced plastic (FRP), ABS alloy plastic, PVC alloy plastic, or similar material, manufactured to produce finished concrete of design, configuration, and surface texture indicated. Fromliners shall be continuous, one piece. No horizontal joints shall be acceptable unless the applicable height exceeds the available formliner height. Provide formliners with inherent form-release surface. Formliners may be manufactured for single-use or multi-use service as appropriate.

G. Leakage Control Materials: Provide materials capable of producing flush, watertight, and nonabsorbent surfaces and joints, and compatible with forming material and concrete ingredients. Seal form edges with gasketing material or sealant placed in the joint in such a way that neither a fin nor groove is made in the face of the cast concrete.

H. Form Release Agent: Commercial formulation, silicone-free form-release agent, designed for use on all types of forms, which will not bond with, stain, nor adversely affect concrete surfaces, and which will not impair subsequent treatment of concrete surfaces requiring bond or adhesion nor impede wetting of surfaces which will be cured with water, steam, or curing compounds.

I. Plugged Cone Form Ties: Rod type, with ends or end fasteners which can be removed without spalling the concrete and which leave a hole equal in depth to the required reinforcement clearance. Form ties shall be of a design in which the hole left by the removed end or end fastener is easily filled to match the surface of the hardened concrete. Provide removable cones one and a fourth inches in diameter by one and a half inches deep. Provide preformed mortar plugs to match the color of the concrete, recessed one fourth inch, adhered with an approved epoxy adhesive.

J. Inserts: Cast stainless steel or welded stainless steel, Type 316 or similar 300 Series, complete with anchors to concrete and fittings such as bolts, wedges, and straps. Provide hanger inserts spaced to match grid of suspended ceiling.

K. Dovetail Anchor Slots: 22 gage or heavier galvanized steel dovetail anchor slots, for anchoring of masonry veneer with galvanized steel dovetail anchors provided under Division 4, Masonry.

L. Chamfer Strips: Three fourths inch by three fourths inch triangular fillets milled from clear, straight-grain pine, surfaced each side, or extruded vinyl type with or without nailing flange.

M. Miscellaneous Joint Strips: Preformed strips for reveals, rustications, and similar joints fabricated of wood, metal, or plastic.

N. Waterstops: Refer to Section 03 15 13, Waterstops, for requirements.

2.02 FABRICATION

A. Formwork, General: Fabricate forms in accordance with approved Shop Drawings. Maintain forms clean, smooth, and free from imperfections and distortion. Fabricate forms for architectural concrete in accordance with applicable requirements of ACI 301.

B. Joints:

1. Arrange form panels in symmetrical patterns conforming to general lines of the structure.

2. Unless otherwise indicated, orient panels on vertical surfaces with long dimension horizontal, and make horizontal joints level and continuous.

3. Align form panels on each side of the panel joint with fasteners common to both panels, and in a manner which will result in a continuous, unbroken concrete plane surface.

C. Steel Forms: Use material which is clean, smooth, and free from warps, bends, kinks, rust, cracks, and matter which may stain concrete. Fabricate panels in accordance with approved Shop Drawings. Deflection between form supports from concrete placement shall not exceed 1/240 of the span length.

PART 3 – EXECUTION

3.01 LAYOUT OF FORMWORK

A. Locate and stake out all forms and establish all lines, levels, and elevations.

3.02 CONSTRUCTION

A. Formwork:

1. Construct formwork in accordance with the approved Shop Drawings, and in a manner that will produce finished concrete surfaces conforming to indicated design and within specified tolerances. Formwork for concrete not exposed to view in the finished work may be constructed of any material that will adequately support the weight of the concrete.

2. Make joints and seams mortar-tight. Install leakage control materials in accordance with the manufacturer's installation instructions, and in a manner that will maintain a smooth continuity of plane between abutting form panels and which will resist displacement by concreting operations.

3. Kerf wood inserts for forming keyways, reglets, and recesses in a manner that will prevent swelling and ensure ease of removal.

4. Maintain forms clean and free from indentations and warpage. Do not use rust-stained steel surfaces for forms in contact with concrete. Do not sandblast steel form surfaces to remove rust or mill scale; remove these imperfections by grinding.

5. Brace temporary closures to prevent warpage or displacement and set tightly against forms in a manner that will prevent loss of concrete mortar.

6. Support joints with extra studs or girts, and in a manner that will ensure true, square intersections.

7. Assemble forms in a manner that will facilitate their removal without damage to the concrete.

8. Construct molding shapes, recesses, and projections with smooth finish materials and install in forms with sealed joints.

9. Provide camber in formwork as required to compensate for deflections caused by weight and pressures of fresh concrete and construction loads and as otherwise indicated. Provide camber strips to compensate for deflections due to permanent loads and long-term deflections due to shrinkage and creep as required.

10. Provide construction openings in forms where required for concrete pour pockets, vibrator access holes, and inspection openings to aid in proper placement and consolidation of concrete, and close up openings during placement of concrete as applicable.

11. Provide inspection and cleanout openings in forms at bottom of walls and columns and elsewhere as required. Do not close cleanouts until inspected and accepted by the Engineer just before placing concrete.

12. Drill air escape holes in bottom members of blockouts.

13. Ensure that formed stair risers within a stair run are equal.

B. Edge Forms and Screeds for Slabs: Set edge forms or bulkheads and intermediate screeds for slabs to obtain required elevations and contours in the finished slab surface. Support screeds substantially without penetrating waterproof membranes and vapor barriers.

C. Corner Treatment: Form chamfers with three fourths inch on each leg, unless otherwise indicated, and accurately shape and surface in a manner which will produce uniformly straight lines and edge joints and which will prevent mortar runs. Extend terminal edges to limits, and miter chamfer strips at changes in direction.

D. Construction Joints:

1. Locate joints as indicated. Support forms for joints in concrete so as to rigidly maintain their positions during placement, vibration, and curing of concrete. Install keys in all joints.

2. Locate and install construction joints, for which locations are not indicated, so as not to impair strength and appearance of the structure, and indicate such joints on Shop Drawings. Locations of construction joints require approval of the Engineer.

3. Position joints perpendicular to longitudinal axis of pier, beam, or slab as the case may be.

4. Locate joints in walls, vertically as indicated; at top of footing; at top of slabs on grade; at bottom of door openings; and at underside of the deepest beam or girder framing into wall; or as required to conform to indicated details.

5. Provide keyways as indicated in construction joints in walls and slabs, and between walls and footings unless otherwise indicated. Place construction joints perpendicular to the main reinforcement. Continue reinforcement across construction joints.

E. Load Supports: Loads for construction of roof slab and suspended floor slabs shall be carried down to on-grade base slabs. These loads shall not be carried by intermediate slabs at any time. Formwork loads shall be carried only by structural elements that are supported directly by footings.

F. Conform with Existing Asphalt Concrete (AC) Paving: Existing AC paving shall be sawcut with a clean butt joint, a minimum of 12 inches from the proposed formwork. The AC plug section shall be installed per Sections 32 11 17, Aggregate Subbase Courses, 32 11 23, Aggregate Base Courses, and 32 12 16, Asphalt Paving, as applicable. AC plug section shall match existing AC section with the AC plug having a AC depth of no less than 6 inches.

3.03 EMBEDDED ITEMS AND OPENINGS IN CONCRETE

A. Install conduit, pipe sleeves, waterstops, appliance boxes, frames for items recessed in walls, door frames, drains, metal ties, inserts, nailing strips, blocking, grounds, and other fastening devices required for anchorage or attachment of other work. Firmly secure products in position, located accurately as indicated, before beginning concrete placement.

B. Provide openings in concrete for passage of ducts, and provide clearances therefore as indicated on approved Shop Drawings.

C. Where masonry walls will be tied to concrete construction in future construction, use dovetail anchor slots positioned for maximum flexibility for masonry installation.

3.04 FORM RELEASE MATERIAL

A. Coat form contact surfaces with approved form release material before reinforcement is placed. Do not allow excess form release material to accumulate in the forms or to come into contact with surfaces that are required to be bonded to fresh concrete such as concrete reinforcement and embedded items. Apply form release material in compliance with manufacturer's application instructions.

B. Coat steel forms with non-staining, rust-preventive form release material or otherwise protect against rusting.

C. Apply form release material to bolts and rods that are to be removed or that are to be free to move.

3.05 REMOVAL OF FORMS

A. Remove forms by methods which will not injure, mar, gouge, or chip concrete surfaces, overstress concrete members, or distort formwork. Use air pressure or other approved methods. Do not pry against concrete. Cut off nails flush. Leave surfaces clean and unblemished.

1. Where early form removal is not necessary, leave forms in place at least 72 hours, unless otherwise approved by the Engineer.

B. When repair of surface defects or finishing is required at an early age, forms may be removed as soon as the concrete has hardened sufficiently to resist damage from removal operations and its own weight.

1. Concrete work that is damaged by removal operations shall be repaired as specified in Section 03 35 00, Concrete Finishing. Where exposed surfaces are damaged beyond acceptable repairing measures, the damaged concrete shall be removed and replaced with new concrete.

C. Top forms on sloping surfaces of concrete may be removed as soon as the concrete has attained sufficient stiffness to prevent sagging. Any needed repairs or treatment required on such sloping surfaces shall be performed at once and shall be followed by the specified curing.

D. Wood forms for wall openings shall be loosened as soon as this can be accomplished without damage to the concrete.

E. Formwork for columns, walls, sides of beams, and other parts not supporting the weight of the concrete may be removed as soon as the concrete has hardened sufficiently so as not to be damaged by removal operations.

F. Forms and shoring in the formwork used to support the weight of concrete in beams, suspended slabs, girders, and other structural members shall remain in place until the concrete has reached adequate strength and stiffness to support itself. Forms shall not be removed before the concrete has reached a minimum of 70 percent of the indicated design compressive strength, unless otherwise approved in writing by the Engineer.

G. When shores and other vertical supports are so arranged that the non-load-carrying form-facing material may be removed without loosening or disturbing the shores and supports, the facing material may be removed at an earlier age provided the concrete surfaces are not damaged by such earlier removal.

H. Plan reshoring operations in a manner that will ensure that areas of new construction will not be required to support their own weight. Reshoring shall be in place before shoring is removed. During reshoring, do not permit live loads on new construction. Do not locate reshores in a manner and location that will overstress members or induce tensile stresses where reinforcing bars have not been provided.

I. When removal of formwork or reshoring is based on the concrete reaching a specified strength, the concrete shall be presumed to have reached this strength when test cylinders, field cured along with the concrete they represent, have reached the strength specified for removal of formwork or reshoring. Except for the field curing and age at test, the cylinders shall be molded and tested as specified in Section 03 05 15, Portland Cement Concrete.

3.06 FIELD QUALITY CONTROL

A. Before placing concrete, check lines and grades of erected formwork and positioning of embedded inserts, blockouts, and joints for correctness. Verify that embedded piping and conduit are free from obstructions. Make corrections or adjustments to ensure proper size and location of concrete members and stability of forming systems.

B. While placing concrete, provide quality control to assure that formwork and related supports have not been displaced, that loss of cement paste through joints is prevented, and that completed work will be within specified tolerances.

C. During form removal, verify that architectural features meet the form and texture requirements of the samples approved by the Engineer.

3.07 DETECTION OF MOVEMENT

A. Check movement using methods, such as plumb lines, tell tales, and survey equipment, to detect movement of formwork during concrete placement.

3.08 RE-USE OF FORMS

A. Clean and repair surfaces of forms to be reused in the work. Split, frayed, delaminated, or otherwise damaged form facing material will not be acceptable. Remove such material from the site. Apply form release coating as specified for new formwork.

B. Align and secure joints in a manner that will preclude offsets. Do not use patched forms for exposed concrete surfaces.

END OF SECTION 03 11 00

SECTION 03 11 14

FALSEWORK

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Layout of falsework.

B. Falsework construction.

C. Removal of falsework.

1.02 MEASUREMENT AND PAYMENT

A. Measurement: Falsework for concrete structures will not be measured separately for payment.

B. Payment: Falsework for concrete structures will be paid for as part of the Contract unit price or lump-sum price for the associated concrete work as indicated in the Bid Schedule of the Bid Form.

1.03 REFERENCE STANDARDS

A. American Society for Testing and Materials (ASTM):

1. ASTM A36/A36M Specification for Carbon Structural Steel

B. California Code of Regulations, Title 8:

1. Division 1, Chapter 4, Subchapter 4, Construction Safety Orders

C. State of California, Department of Transportation (Caltrans), Standard Specifications:

1. Section 12 Temporary Traffic Control

2. Section 48 Temporary Structures, Section 48-2, “Falsework”

D. State of California, Department of Transportation (Caltrans), Office of Structure Construction:

1. Falsework Manual

E. West Coast Lumber Inspection Bureau (WCLIB):

1. WCLIB No. 17 Standard Grading Rules

1.04 FALSEWORK DESIGN CRITERIA

A. Regulatory Requirements: Falsework shall comply with applicable requirements of the California Code of Regulations, Title 8, Construction Safety Orders.

B. Design Standards:

1. In addition to the requirements specified herein, comply with the Caltrans Standard Specifications Section 48-2, “Falsework,” and the Caltrans Falsework Manual.

2. All lumber, posts, and timbers shall be graded and grade-marked in accordance with WCLIB No. 17. Provide stress-graded lumber for all structural members, conforming with the above-specified WCLIB No. 17.

C. Design Loads: Design loads for falsework shall conform with applicable requirements of Caltrans Standard Specifications, Section 48, Temporary Structures, and the Caltrans Falsework Manual.

D. Design Stresses, Loadings, and Deflections: The maximum allowable design stresses, loadings and deflections shall conform with applicable requirements of Caltrans Standard Specifications, Section 48, Temporary Structures, and the Caltrans Falsework Manual.

1.05 SUBMITTALS

A. Requirements: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures. Shop Drawings and supporting calculations for falsework shall be submitted to the Engineer for review and approval.

B. Shop Drawings and Calculations:

1. Submit drawings and design calculations, prepared by a civil or structural engineer currently registered in the State of California for all falsework proposed for concrete structures requiring falsework support. Falsework design calculations shall include the stresses and deflections in load supporting members.

2. Where the height of any portion of the falsework, as measured from the ground line to the soffit of the superstructure, exceeds 14 feet, or where any individual falsework clear-span length exceeds 16 feet, or where provision for vehicular or pedestrian traffic through the falsework is made, such drawings shall be sealed and signed by an engineer who is currently registered as a civil or structural engineer in the State of California.

3. Except for placement of foundation pads and piles, do not start construction of any unit of falsework until the Engineer has approved the Shop Drawings and calculations for that unit.

4. Falsework forms shall be designed to carry the load imposed upon them without exceeding the estimated soil bearing values and anticipated settlements, and without relying on existing structures for stability or support.

5. When footing type foundations are proposed, determine the bearing value of the soil and show the values assumed in the design of the falsework on the falsework drawings.

6. When pile type foundations are proposed, show the maximum horizontal distance that the top of a falsework pile may be pulled out of position to support its cap. Also, show the maximum allowed deviation of the top of the pile, in its final position, from a vertical line through the point of fixity of the pile.

7. Show anticipated total settlements of falsework and forms. These shall include falsework footings settlement and joint take-up. Falsework supporting deck slabs and overhangs on girder bridges shall be designed so that there will be no differential settlement between the girders and the deck forms during placement of deck concrete.

8. Foundations for individual steel towers where the maximum leg load exceeds 30 kips shall be designed and constructed to provide uniform settlement under all legs of each tower under all loading conditions.

9. The support systems for form panels supporting concrete deck slabs and overhangs on girder bridges shall also be considered to be falsework, and shall be designed as such.

10. Temporary bracing shall be provided, as necessary, to withstand all imposed loads during erection, construction, and removal of falsework. The falsework drawings shall show provisions for such temporary bracing or methods to be used to conform to this requirement during each phase of erection, construction, and removal. Wind loads shall be included in the design of such bracing or methods.

11. Design of falsework will not be approved by the Engineer unless based on the use of loads and conditions that are no less severe than those specified in Article 1.04.C herein, and on the use of stresses and deflections that are no greater than those specified in Article 1.04.D. The Contractor shall be responsible for the proper evaluation of falsework materials and for the design of falsework to safely carry the actual loads imposed.

C. Forming System: Furnish form design and materials data for each forming system to be used for exposed surfaces. Coordinate with the work of Section 03 11 00, Concrete Forming.

D. For falsework over or adjacent to BART tracks, Criteria and Design shall be submitted to BART Engineering for review and approval.

1.06 SPECIAL LOCATIONS

A. In addition to the Falsework Design Criteria specified herein, falsework over or adjacent to roadways or railroads that are open to traffic shall be designed and constructed in accordance with applicable requirements of Caltrans Standard Specifications, Section 48, Temporary Structures, the Caltrans Falsework Manual, and the applicable requirements of the railroads.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Requirements: Materials for falsework shall conform with applicable requirements of the Caltrans Standard Specifications, Section 48, Temporary Structures, and the Caltrans Falsework Manual, except as indicated or specified otherwise herein.

B. Lumber: All falsework lumber, posts, and timbers shall be graded and grade-marked in accordance with WCLIB No. 17, dressed or rough. Provide stress-graded lumber for all falsework lumber, conforming with the above-specified WCLIB No. 17.

C. Steel: ASTM A36/A36M, structural shapes as required.

PART 3 – EXECUTION

3.01 LAYOUT OF FALSEWORK

A. Locate and stake out all forms and falsework, and establish all lines, grades, and elevations.

3.02 FALSEWORK CONSTRUCTION

A. Construct falsework to conform with the approved falsework Shop Drawings and applicable requirements of the Caltrans Standard Specifications, Section 48, Temporary Structures, and the Caltrans Falsework Manual.

3.03 REMOVAL OF FALSEWORK

A. Release and removal of falsework shall conform with applicable requirements of the Caltrans Standard Specifications, Section 48, Temporary Structures, and the Caltrans Falsework Manual.

END OF SECTION 03 11 14

SECTION 03 15 00

CONCRETE ACCESSORIES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Joint fillers.

B. Joint sealing compound.

C. Elastomeric joint seals.

D. Plastic pads, spacers, and fillers.

1.02 RELATED SECTIONS

A. Waterstops are specified in Section 03 15 13, Waterstops.

B. Elastomeric bearing pads are specified in Section 03 15 15, Elastomeric Bearing Pads.

C. Elastomeric noise abatement seals at trackway acoustical barriers are specified in Section 03 40 00, Precast Concrete.

D. Metal stair nosings, armor protection for concrete edges, metal anchors, inserts, sleeves, and various metal accessories related to cast-in-place concrete work are specified in Section 05 50 00, Metal Fabrications.

E. Expansion and seismic control joints are specified in Section 07 95 00, Expansion Control.

F. Calking and sealants related to the sealing of openings in walls and weatherproofing of station structures are specified in Section 07 90 00, Joint Protection.

1.03 MEASUREMENT AND PAYMENT

A. Measurement: Concrete accessories will not be measured separately for payment.

B. Payment: Concrete accessories will be paid for as part of the indicated Contract unit price or lump-sum price for the associated concrete or paving work as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1.	ASTM C272/ C272M	Standard Test Method for Water Absorption of Core Materials for Sandwich Constructions
2.	ASTM C578	Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation
3.	ASTM C920	Standard Specification for Elastomeric Joint Sealant
4.	ASTM D994/ D994M	Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type)
5.	ASTM D6690	Standard Specification for Joint and Crack Sealants, Hot-Applied, for Concrete and Asphalt Pavements
6.	ASTM D1621	Standard Test Method for Compressive Properties of Rigid Cellular Plastics
7.	ASTM D1622/ D1622M	Standard Test Method for Apparent Density of Rigid Cellular Plastics
8.	ASTM D1751	Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
9.	ASTM D2628	Standard Specification for Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements
10.	ASTM D2835	Standard Specification for Lubricant for Installation of Preformed Compression Seals in Concrete Pavements
11.	ASTM D3542	Standard Specification for Preformed Polychloroprene Elastomeric Joint Seals for Bridges
12.	ASTM D4070	Standard Specification for Adhesive Lubricant for Installation of Preformed Elastomeric Bridge Compression Seals in Concrete Structures
13.	ASTM E84	Standard Test Method for Surface Burning Characteristics of Building Materials

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit drawings showing locations of all joints to be filled and sealed.

C. Product Data: Submit manufacturers' product data of joint fillers, sealing compounds, elastomeric joint seals, and plastic materials, verifying compliance with specified requirements.

D. Samples: Submit 12-inch long sample of joint filler and elastomeric joint seals and one pint can of sealing compound.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Joint Filler: Premolded, of sizes and thickness indicated, conforming to ASTM D994/D994M or ASTM D1751, as applicable.

1. For structural joints and joints subject to movement, provide elastomeric joint seals conforming to ASTM D2628 or ASTM D3542, as applicable.

B. Joint Sealing Compound: Concrete joint sealant, conforming to ASTM C920 (Type S or M, Grade NS, Class 25, Use T), ASTM D6690, as applicable, for sealing of expansion (isolation) and contraction (control) joints in slabs and at junctions of slabs and vertical surfaces.

Color of joint sealant shall be as selected by the Engineer from manufacturer's standards.

1. For asphalt pavements, provide ASTM D6690 sealant only. For concrete pavements and roadways, provide ASTM C920 sealant.

C. Elastomeric Joint Seals: Preformed solid or multi-web design, virgin crystallization-resistant polychloroprene (neoprene) conforming with ASTM D2628 or ASTM D3542, as applicable. Seals shall be designed to function in a compressed installation mode.

1. Lubricant Adhesive: For concrete pavement, provide ASTM D2835 lubricant adhesive. For concrete structures, provide ASTM D4070 lubricant adhesive.

D. Plastic Pads, Spacers, and Fillers: Extruded closed-cell polystyrene rigid board meeting requirements of ASTM C578, Type V, with the following physical properties:

1. Minimum weight and density when tested in accordance with ASTM D1622/D1622M: 3.0 pounds per cubic foot.

2. Minimum compressive strength when tested in accordance with ASTM D1621: 100 pounds per square inch.

3. Maximum water absorption when tested in accordance with ASTM C272/C272M: 0.10 percent by volume.

4. Maximum allowable flame spread when tested in accordance with ASTM E84: 10 flame-spread index.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Verify that joint surfaces are dry to the extent necessary for successful sealant application and long service life as recommended by the sealant manufacturer.

B. Verify also that ambient and concrete-surface temperatures and humidity are within the ranges recommended by the manufacturer for successful sealant application.

3.02 PREPARATION

A. Thoroughly clean joints free of dirt, debris, dust, and laitance. Protect waterstops during cleaning.

B. Joint surfaces shall be surface dry when seals are applied.

C. Prime joint surfaces, where required, as recommended by the manufacturer of the joint sealing compound or elastomeric joint seal, as applicable.

D. Mix multi-component sealing compound as recommended by the manufacturer.

3.03 INSTALLATION

A. Installation/Application Requirements: Joint fillers and sealing compounds shall be installed in accordance with the respective manufacturers' installation and application instructions. Comply also with ASTM D6690, Appendix X1, for application of sealants, as applicable. Coordinate the placement of joint fillers and securing them in position with the work of Section 03 11 00, Concrete Formwork.

B. Expansion (Isolation) Joints:

1. Provide premolded joint filler to full depth of slabs, less 1/2 inch. Install joint filler with top edge 1/2 inch below the surface, and tool adjacent concrete edges to a 1/4-inch radius. Use steel pins to hold material in place during placing and floating of concrete. Finished joints shall be tight and leakproof.

2. After a minimum of 28 Days after slabs have been placed and finished, fill expansion joints with joint sealing compound to 1/8 inch below surface of slabs. No traffic shall be permitted to travel over sealed joints until sealing compound has properly cured.

C. Contraction (Control) Joints: Saw-cut contraction joints and weakened plane joints shall be filled with joint sealing compound in areas and locations indicated. Joints shall be filled and tooled flush to within 1/16 inch of the slab surface.

D. Roadway and Bridge: Provide elastomeric joint seals as applicable to the conditions. Install as indicated and in accordance with the manufacturer's installation instructions and recommendations.

E. Plastic Pads, Spacers, and Fillers: Install as indicated over or against clean surfaces. Apply adhesive where required to hold material in place.

END OF SECTION 03 15 00

SECTION 03 15 13

WATERSTOPS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Waterstops.

1.02 MEASUREMENT AND PAYMENT

A. Measurement: Waterstops for concrete will not be measured separately for payment.

B. Payment: Waterstops for concrete will be paid for as part of the indicated Contract unit price or lump-sum price for the associated concrete or paving work as indicated in the Bid Schedule of the Bid Form.

1.03 REFERENCES

A. U. S. Army Corp of Engineers, Concrete Research Division (CRD):

1. CRD-C513 Corps of Engineers Specifications for Rubber Waterstops

2. CRD-C572 Corps of Engineers Specifications for Polyvinylchloride Waterstops

1.04 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit drawings showing locations of all joints to receive waterstops and methods of supporting waterstops in forms without displacement from pressure of concrete placement.

C. Product Data: Submit manufacturers' product data of proposed waterstops for review.

D. Samples: Submit 12-inch long sample of typical waterstop and sample of field splice.

1.05 STORAGE AND HANDLING

A. Store waterstops in a manner that provides free circulation of air around the material.

B. Protect waterstop material from direct sunlight while in storage, and when only partially encased in concrete for over 48 hours.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Waterstops shall conform to CRD-C513 or CRD-C572, as applicable.

B. Material for rubber waterstops shall be natural rubber, suitable synthetic rubber, or a blend of natural and suitable synthetic rubber.

C. Material for PVC waterstops shall be an elastomeric plastic compound, the basic resin of which shall be polyvinyl chloride and containing any additional resins, plasticizers, or other materials needed for the material to comply with the requirements specified.

D. Waterstops shall be manufactured by such a process that they will be dense, homogenous, and free from holes and other imperfections. The cross section of the waterstop shall be uniform and symmetrical along its entire length.

E. Waterstops shall have the cross-sectional shape and dimensions indicated. Split-leg waterstops will not be permitted.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Provide waterstops for all construction joints in exterior walls, base slabs, suspended slabs, roof slabs, and other locations as indicated.

B. Install waterstops accurately in place and secure rigidly against movement by methods adequate to assure proper support and embedment during the placement of concrete.

C. Unless otherwise indicated, install waterstops so that embedment in concrete will be equal on both sides of the joint.

D. Provide factory made waterstop fabrications for changes of direction, intersections, and transitions. Butt joint splice shall only occur in the straight segments at the field.

E. Install waterstops in the longest practicable length, with joints spliced to form a continuous watertight seal for the full length of the joint.

F. Carefully place and consolidate concrete to ensure a complete filling and bond between the concrete and waterstop. A cement-sand grout slurry may be used where necessary to assure contact and bond of waterstop and concrete without voids.

G. When installed in an expansion joint, locate waterstop so that the closed hollow center-bulb remains in the gap of the joint, to allow for maximum elongation with minimum stress on that portion of the waterstop embedded in the concrete. Install expansion joint material and a sealant in the joint, as indicated, to prevent foreign matter from accumulating in the joint area. When a sealant is used, place a separator (backer rod) between the sealant and the waterstop to assure that both the waterstop and sealant perform properly.

H. Repair or replace damaged, defective or misaligned waterstop material in accordance with the manufacturer's instructions.

3.02 SPLICING

A. PVC waterstops shall be butt-spliced by applying a thermostatically controlled electric source of heat and welding material in accordance with the manufacturer's splicing instructions. Rubber waterstops shall be butt-spliced by field vulcanizing. Lapping and use of adhesive or solvent for splicing shall not be allowed. Splices shall have a tensile strength not less than 60 percent of the unspliced materials' tensile strength. Maintain continuity of waterstop and bulbs.

3.03 FIELD QUALITY CONTROL

A. Waterstops and their joints shall be inspected for misalignment, bubbles, inadequate bond, porosity, cracks, offsets, and other defects that could reduce the effectiveness of joints against water penetration. Waterstop splicing defects which are not acceptable include, but not limited to the following:

1. Misalignment of center bulb, ribs, and end bulbs greater than 1/16 inch.
2. Misalignment which reduces waterstop cross section area greater than 15 percent.
3. Bond failure at joint deeper than 1/16 inch or 15 percent of material thickness.
4. Visible porosity in the weld.
5. Charred or burnt material.
6. Bubbles or inadequate bonding.
7. Visible signs of splice separation when cooled splice (24 hours or greater) is bent by hand at sharp angle.
8. Misalignment of waterstop splice resulting in misalignment of waterstop in excess of 1/2 inch or 10 feet.

END OF SECTION 03 15 13

SECTION 03 15 15

ELASTOMERIC BEARING PADS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Plain elastomeric bearing pads.

B. Fabric-reinforced laminated bearing pads.

C. Steel-reinforced laminated bearing pads.

1.02 MEASUREMENT AND PAYMENT

A. Measurement: Elastomeric bearing pads will not be measured separately for payment.

B. Payment: Elastomeric bearing pads will be paid for as part of the indicated Contract unit price or lump-sum price for the associated concrete work as indicated in the Bid Schedule of the Bid Form.

1.03 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):

1. AASHTO M251 — Standard Specifications for Plain and Laminated Elastomeric Bridge Bearings

B. American Society for Testing and Materials (ASTM):

1. ASTM A36/A36M — Standard Specification for Carbon Structural Steel
2. ASTM A1011/A1011M — Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability, and Ultra High-Strength
3. ASTM D395 — Standard Test Methods for Rubber Property - Compression Set
4. ASTM D412 — Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers – Tension
5. ASTM D429 — Standard Test Methods for Rubber Property - Adhesion to Rigid Substrates
6. ASTM D573 — Standard Test Method for Rubber - Deterioration in an Air Oven

7. ASTM D624 — Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers
8. ASTM D746 — Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact
9. ASTM D1149 — Standard Test Method for Rubber Deterioration - Cracking in an Ozone-Controlled Environment
10. ASTM D2240 — Standard Test Method for Rubber Property - Durometer Hardness
11. ASTM D4014 — Standard Specification for Plain and Steel-Laminated Elastomeric Bearings for Bridges

1.04 DEFINITIONS

A. As used in these Specifications, the word “elastomer” or “elastomeric” means “rubber”; the words are interchangeable.

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Product Data: Submit manufacturer’s product data of elastomeric bearing pads for review.

C. Samples: Furnish one sample elastomeric bearing pad for each type of pad used in the Work. Samples will be selected by the Engineer at random from the lots delivered to the jobsite.

D. Certificates of Compliance: Submit certificates of compliance certifying that materials and fabrication of elastomeric bearing pads comply with these Specifications as applicable.

PART 2 – PRODUCTS

2.01 TYPES OF BEARING PADS

A. Plain Elastomer Type: Molded elastomeric compound, or cut from previously molded strips or slabs, or extruded and cut to length, with smooth surfaces and cut edges.

B. Fabric-Reinforced Laminated Type: Laminated pads consisting of alternate layers of elastomeric compound and glass fabric reinforcement bonded together, with top and bottom layers of reinforcement uniformly covered with 1/8 inch of elastomer.

C. Steel-Reinforced Laminated Type: Laminated pads consisting of alternating steel laminates and internal elastomer laminates bonded together, with top and bottom layers of steel reinforcement uniformly covered with 1/4 inch of elastomer. Exposed sides shall be covered with 1/8 inch of elastomer.

2.02 MATERIALS

A. Elastomeric Compound/Elastomer: Virgin crystallization-resistant polychloroprene as the raw elastomer. Physical requirements of the elastomeric compound include the following:

1. Physical Properties:

    a. Hardness: ASTM D2240, Type A durometer, 60, plus or minus 5.

    b. Tensile Strength: ASTM D412, 2500 psi minimum.

    c. Ultimate Elongation: ASTM D412, 350 percent minimum.

2. Heat Resistance: ASTM D573, 70 hours at 212 degrees Fahrenheit.

    a. Change in durometer hardness: plus 10 points maximum.

    b. Change in tensile strength: minus 15 percent maximum.

    c. Change in ultimate elongation: minus 40 percent maximum.

3. Compression Set: ASTM D395, Method B, 22 hours at 212 degrees Fahrenheit: 35 percent maximum.

4. Ozone Cracking: ASTM D1149, 100 pphm ozone in air by volume, 20 percent strain, 104 plus or minus 2 degrees Fahrenheit: no cracks.

5. Adhesion: ASTM D429, Method B, bond made during vulcanization: 40 pounds per square inch.

6. Tear Strength: ASTM D624, Die C, 180 pounds per inch minimum.

7. Brittleness: ASTM D746 Section 9.1.2, Low temperature brittleness at minus 40 degree Fahrenheit: no failure.

B. Fabric Laminates: Fabric reinforcement shall be woven from one-hundred percent glass fibers of “E” type yarn with continuous fibers. Minimum thread count in either direction shall be 25 threads per inch. Fabric shall have either a crow foot or an 8 Harness Satin weave. Each ply of fabric shall have a breaking strength of not less than 800 pounds per inch of width in each direction. Fabric reinforcement shall be single ply at top and bottom surfaces of the pad and double ply within the pad.

C. Steel Laminates: Steel for internal reinforcement laminates shall conform with the following requirements as indicated:

1. Steel 3/16-inch Thick and Over: Steel plate conforming to ASTM A36/A36M

2. Steel Under 3/16-inch Thick: Steel sheet conforming to ASTM A1011/A1011M.

D. Adhesive: Adhesive for the installation of bearing pads to concrete and steel bearing surfaces shall be a solvent-free adhesive as appropriate for this particular installation.

2.03 FABRICATION

A. Plain elastomer bearing pads and laminated steel bearing pads shall conform to the applicable requirements of ASTM D4014. Laminated fabric bearing pads shall conform to the applicable requirements of AASHTO M251.

B. Pads 1/2 inch or less in thickness shall be either all elastomer or laminated. Pads over 1/2 inch thick shall be laminated. Stacking of individually laminated pads to attain thicknesses over 1/2 inch or the cold bonding of individual laminate pads is not acceptable.

C. Plain elastomer bearing pads shall be molded individually, or cut from previously molded strips or slabs, or extruded and cut to size. Cutting shall produce a smooth surface and no heating of the elastomer.

D. Laminated pads shall have reinforcement every 1/2 inch through the entire thickness. Reinforcement shall be parallel to the top and bottom surfaces of the pad. Elastomer and reinforcement together shall not exceed 1/2 inch in thickness per lamination.

E. Laminated bearing pads shall be molded as a single unit under pressure and heat. Bonding of elastomer to reinforcement laminates shall be carried out during molding. Elastomer at outer edges of bonds to external load plates shall be shaped to avoid stress concentrations.

F. Internal steel laminates shall be free of sharp edges. Top and bottom steel laminates shall be covered uniformly with 1/4 inch of elastomer. Sides shall be covered uniformly with 1/8 inch of elastomer.

G. External load plates shall be protected from rusting.

H. Comply with ASTM D4014 for fabrication tolerances.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install elastomeric bearing pads at locations indicated in accordance with indicated details.

B. Apply adhesive to clean concrete bearing surface to a minimum thickness of 1/8 inch, and set bearing pads on adhesive bed as indicated.

END OF SECTION 03 15 15

SECTION 03 20 00

CONCRETE REINFORCING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Steel reinforcing bars.

B. Galvanized reinforcing bars.

C. Epoxy-coated reinforcing bars.

D. Wire and spiral reinforcement.

E. Welded steel wire fabric.

F. Steel bar mats.

G. Tie wire.

H. Accessories.

I. Welding Electrodes.

J. Exothermic Metal-filled Sleeve.

K. Mechanical Splice Coupler.

1.02 RELATED SECTIONS

A. Reinforcing steel for shotcrete is specified in Section 03 37 13, Shotcrete.

B. Reinforcing steel for prestressed concrete and precast concrete is specified in Section 03 05 18, Prestressed Concrete, and Section 03 40 00, Precast Concrete.

C. Reinforcement for masonry is specified in Section 04 22 00, Concrete Unit Masonry.

D. Reinforcing steel for piles, drilled shaft foundations, portland cement concrete paving, concrete curbs, gutters, and walks, and utility structures is specified in their respective Sections.

1.03 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for concrete reinforcement will be either by the lump-sum method or by the unit-price method as determined by the listing of the bid item for concrete reinforcement indicated in the Bid Schedule of the Bid Form.

B. Lump Sum: If the Bid Schedule indicates a lump-sum for concrete reinforcement, the lump-sum method of measurement and payment will be in accordance with Section 01 20 00, Price and Payment Procedures, Article 1.03.

C. Unit Prices: If the Bid Schedule indicates a unit price for concrete reinforcement, the unit-price method of measurement and payment will be as follows:

1. Measurement:

a. Reinforcing steel bars, including galvanized and epoxy-coated reinforcements, and wire reinforcement will be measured for payment by the pound, complete in place.

1) Weights will be determined from computations based on the nominal weights listed in ACI 318, Appendix on Steel Reinforcement Information. For galvanized and epoxy-coated reinforcements, the weights of the zinc and epoxy coatings will not be included.

2) Laps of bars for splices indicated will be measured for payment. Splices for Contractor's convenience will not be measured for payment. When bars are spliced by welding, the weight for payment will be as computed for lapped splices.

b. Welded wire fabric will be measured for payment by the square yard of each configuration placed. Quantities will be the actual number of square yards measured complete in place, with no allowance for overlap.

c. The following concrete reinforcement will be measured for payment under this Section:

1) Reinforcing steel, including spirals, for drilled shaft foundations as specified in Section 31 63 29, Drilled Concrete Piers and Shafts.

2) Reinforcing steel for concrete paving as specified in Section 32 13 13, Concrete Paving.

3) All cast-in-place concrete structures and slabs as specified in Section 03 30 00, Cast-In-Place Concrete, except as specified under Article 1.03.C.1.d herein.

4) Reinforcing steel for shotcrete as specified in Section 03 37 13, Shotcrete.

5) Reinforcing steel for cast-in-place prestressed concrete (post-tensioned), except prestressing steel, as specified in Section 03 05 18, Prestressed Concrete.

d. The following concrete reinforcement will not be measured separately for payment, but will be included in the unit measurement of the associated concrete work:

1) Reinforcing steel for concrete piles as specified in Section 31 62 00, Driven Piles.

2) Reinforcing steel for concrete curbs, gutters, and walks as specified in Section 32 16 21, Concrete Curbs, Gutters, and Walks.

3) Reinforcing steel for utility structures as specified in Section 33 05 16, Utility Structures.

4) Prestressing steel for prestressed concrete, including concrete reinforcement for precast/prestressed concrete as specified in Section 03 05 18, Prestressed Concrete.

5) Reinforcing steel for precast concrete as specified in Section 03 40 00, Precast Concrete.

6) Reinforcing steel for concrete ductbanks as specified in Section 20 50 16, Underground Ductwork and Structures for Facility Services.

e. The following reinforcement and accessory items will not be measured separately for payment:

1) Clips, ties, bar supports, dowels, spacers, chairs, or other devices for holding reinforcing steel in place, including zinc and epoxy coatings.

2) Additional reinforcing steel for splices permitted by the Engineer for Contractor's convenience.

3) Reinforcing steel and accessories, including zinc and epoxy coatings, required for lump sum items.

2. Payment:

a. Reinforcing steel bars, wire reinforcement, and welded wire fabric will be paid for at the indicated Contract unit prices for the computed quantities as determined by the measurement methods specified above.

b. Payment for reinforcement and accessory items listed under Article 1.03.C.1.e herein will be included in the Contract unit prices for the associated cast-in-place concrete work.

1.04 REFERENCES

A. American Concrete Institute (ACI):

1.	ACI 117	Specification for Tolerances for Concrete Construction and Materials
2.	ACI SP-066	ACI Detailing Manual
3.	ACI 301	Specifications for Structural Concrete
4.	ACI 318	Building Code Requirements for Structural Concrete and Commentary
5.	ACI 439.3R	Types of Mechanical Splices for Reinforcing Bars

B. American Society for Testing and Materials (ASTM):

1.	ASTM A184/A184M	Standard Specification for Wielded Deformed Steel Bar Mats for Concrete Reinforcement

2. ASTM A370 — Standard Test Methods and Definitions for Mechanical Testing of Steel Products
3. ASTM A615/ A615M — Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
4. ASTM A706/ A706M — Standard Specification for Deformed and Plain Low-Alloy Bars for Concrete Reinforcement
5. ASTM A767/ A767M — Standard Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement
6. ASTM A775/ A775M — Standard Specification for Epoxy-Coated Steel Reinforcing Bars
7. ASTM A884/ A884M — Standard Specification for Epoxy-Coated Steel Wire and Welded Wire Reinforcement
8. ASTM A1064/ A1064M — Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, For Concrete
9. ASTM D3963/ D3963M — Standard Specification for Fabrication and Jobsite Handling of Epoxy-Coated Steel Reinforcing Bars
10. ASTM E8/E8M — Standard Test Methods of Tension Testing of Metallic Materials
11. ASTM E165/ E165M — Standard Practice for Liquid Penetrant Examination for General Industry

C. American Welding Society (AWS):

1. AWS D1.4/D1.4M — Structural Welding Code - Reinforcing Steel

D. Concrete Reinforcing Steel Institute (CRSI):

1. CRSI Manual of Standard Practice
2. CRSI Placing Reinforcing Bars

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings:

1. Submit bar lists, bending diagrams and schedules, and placement plans and details for all reinforcing steel. Bar lists shall include weights.

2. Indicate descriptions, details, dimensions, arrangements and assemblies, and locations of reinforcing steel. Include number of pieces, sizes, and markings of reinforcing steel, laps and splices, supporting devices and accessories, and any other information required for fabrication and placement. Indicate any adjustments required as specified in Article 1.06.B.

3. Check Contract Drawings for anchor bolt schedules and locations, anchors, hangers, inserts, conduits, sleeves, blockouts, and any other items to be cast in concrete for possible interference with reinforcing steel. Indicate required clearances on Shop Drawings.

4. Detail reinforcing steel in accordance with requirements of the ACI SP-066. Indicate individual weight of each bar, total weight of each bar size, and total weight of all bars on the list. Base calculated weights upon nominal weights specified in ACI 318, Appendix on Steel Reinforcement Information.

5. For mechanical splice couplers furnish the following:

    a. Certified test reports showing that the couplers meet all of the specified requirements.

    b. Written assembly and installation instructions for each type, model and bar size for which the coupler is designed. Installation instructions shall include typical installation sequence, recommended installation tools, guidelines for laboratory testing of couplers and coupler size designations with corresponding range of bar sizes.

    c. Reports showing the results of all tests.

C. Product Data:

1. Submit manufacturers' product data and installation instructions for proprietary manufactured materials and reinforcement accessories.

2. Submit manufacturers' product data and installation instructions for proprietary exothermic metal splicing systems and proprietary mechanical coupler splicing systems when such splicing methods are permitted.

D. Samples:

1. When galvanized or epoxy-coated reinforcing bars are indicated, furnish two 12-inch long samples and two additional samples bent to minimum radius of the rebar from each size and lot shipped to the jobsite.

2. Samples shall be representative of the materials furnished. These samples, as well as any additional random samples taken by the Engineer, may be tested for specification compliance.

3. Failure of any sample to meet specification requirements shall be cause for rejection of that lot.

E. Certificates:

1. For each lot or load of reinforcing steel delivered to the jobsite, furnish mill affidavits or test reports of compliance or similar certification, certifying the grades and physical and chemical properties of the reinforcing steel and conformance with applicable ASTM Specifications, including ASTM A370.

2. For galvanized and epoxy-coated reinforcing bars, furnish certificates of compliance with ASTM A767/A767M for galvanized bars and with ASTM A775/A775M and D3963/D3963M for epoxy-coated bars.

3. For welders, furnish welding certificates or affidavits attesting to the welders' qualifications to perform the indicated welding in accordance with applicable requirements of AWS D1.4/D1.4M.

4. For exothermic sleeve coupler splicing, furnish certificates or affidavits attesting to the crew's special qualifications to perform the splicing.

1.06 QUALITY CONTROL

A. Tolerances:

1. Fabrication: Fabricate bars to meet the following tolerances:

   a. Sheared length: plus or minus 1 inch.

   b. Depth of truss bars: plus 0, minus 1/2 inch.

   c. Overall dimensions of stirrups, ties and spirals: plus or minus 1/2 inch.

   d. All other bends: plus or minus 1 inch.

   e. Fabrication tolerances not indicated on the Contract Drawings or specified above shall comply with the applicable requirements of ACI 301 and CRSI Manual of Standard Practice, Chapter 7.

2. Placement: Place bars to the following tolerances:

   a. Clear distance to formed surfaces: plus or minus 1/4 inch.

   b. Minimum spacing between bars: minus 1/4 inch.

   c. Top bars in slabs and beams:

      1) Member 8 inches deep or less: plus or minus 1/4 inch.

      2) Member greater than 8 inches, but less than 2 feet deep: plus or minus 1/2 inch.

      3) Members 2 feet or more deep: plus or minus 1 inch.

   d. Crosswise of members: spaced evenly within 2 inches.

   e. Lengthwise of members: plus or minus 2 inches.

f. Placement tolerances not indicated on the Contract Drawings or specified above shall comply with the requirements of ACI 301, ACI 318, ACI 117, and CRSI Manual of Standard Practice, as applicable.

B. Adjustments: Bars may be moved as necessary to avoid interference with other reinforcing steel, conduits, or embedded items. If bars are moved more than one bar diameter, or in excess of the above tolerances, the resulting arrangement of bars shall require the Engineer's approval. Minimum spacings shall not be decreased, and the required number of bars shall be placed. Bars moved to permit access for cleanup operations shall be properly replaced and secured before the start of concrete placement.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Deliver reinforcing bars to the fabricator in bundles, limited to one size and length of bar, securely tied and identified with plastic tags in an exposed position indicating the mill, the melt or heat number, and the grade and size of bars.

B. Deliver steel reinforcement to the jobsite, store, and cover in a manner which will ensure that no damage shall occur to it from moisture, dirt, grease, oil, or other cause which might impair bond with concrete.

C. Deliver steel reinforcement to the jobsite properly tagged and identified, as specified herein in Article 2.03, in accordance with approved Shop Drawings.

D. Handle and store galvanized and epoxy-coated reinforcement in a manner which will prevent damage to the coatings. For epoxy-coated reinforcement, comply with the requirements of ASTM D3963/D3963M.

E. Maintain identification of steel reinforcement after bundles are broken.

F. Provide special facilities for the storage and handling of exothermic materials as recommended by the splicing system manufacturer.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Steel Reinforcing Bars:

1. Deformed Carbon Steel Bars: ASTM A615/A615M.

2. Low-Alloy Steel Bars: ASTM A706/A706M.

3. Weights of Bars: Refer to ACI 318, Appendix on Steel Reinforcement Information.

4. See BART Facility Standards, Facility Design, Criteria, structure, Reinforced Concrete for the application of types and grades of reinforcing steel to the BART facilities.

B. Galvanized Reinforcing Bars: ASTM A706/A706M or ASTM A615/A615M, as applicable, galvanized in accordance with ASTM A767/A767M, Class I coating. Bars shall be cut and bent cold before galvanizing.

C. Epoxy-coated Reinforcing Bars: ASTM A706/A706M or ASTM A615/A615M, as applicable, epoxy-coated in accordance with ASTM A775/A775M and ASTM D3963/D3963M. Coating material shall conform to ASTM A775/A775M and ASTM D3963/D3963M, green in color. Furnish acceptance test reports for each lot of epoxy-coated bars delivered to the site.

D. Wire and Spiral Reinforcement: ASTM A1064/A1064M for plain wire and deformed wire.

E. Welded Steel Wire Fabric - Plain Wire: ASTM A1064/A1064M, wire sizes and center-to-center spacings as indicated.

F. Welded Steel Wire Fabric - Deformed Wire: ASTM A1064/A1064M, wire sizes and center-to-center spacings as indicated.

G. Welded Steel Wire Fabric - Epoxy-Coated: ASTM A884/A884M, wire sizes and center-to-center spacings as indicated.

H. Steel Bar Mats - Deformed Bars: ASTM A184/A184M, using ASTM A706/A706M deformed bars, sizes and spacings of members as indicated, welded or clipped at intersections.

I. Accessories: Provide reinforcement accessories, consisting of bar supports, spacers, hangers, chairs, ties, and similar items as required for spacing, assembling, and supporting reinforcement in place. Conform with CRSI referenced standards and the following requirements:

1. For footings, grade beams, and slabs on grade, provide supports with precast concrete or mortar bases or plates or horizontal runners where wetted base materials will not support chair legs.

2. For exposed-to-view concrete surfaces, where legs of supports are in contact with forms or are in close proximity to finish surfaces, provide supports with legs which are galvanized, plastic-protected, or stainless steel.

3. For galvanized reinforcement, provide all galvanized accessories.

4. For epoxy-coated reinforcement, provide accessories which are nylon-, epoxy, or plastic-coated.

J. Tie Wire: No. 16 gage or heavier, black or galvanized, soft or commercial grade steel tie wire. For galvanized reinforcement, provide zinc-coated wire. For epoxy-coated reinforcement, provide nylon-, epoxy-, or plastic-coated wire. Where tie wire is in close proximity to finish surfaces of exposed-to-view concrete, provide soft stainless steel wire.

K. Welding Electrodes: E90XX low hydrogen electrodes (for shielded metal arc welding.)

L. Exothermic Metal-Filled Sleeve Coupler:

1. System Description: Provide bar splicing connection, produced by a standard exothermic process whereby molten filler metal, contained by a high-strength steel sleeve of larger inside diameter than adjoining bars, is introduced into the annular space between the bars and the sleeve as well as between the ends of the bars. Splicing system shall produce complete fusion with 100 percent penetration of the joint.

2. Spliced Strength in Tension: 125 percent of the yield strength of connected reinforcing bars.

M. Mechanical Splice Coupler:

1. System Description: Provide bar-splicing connections, produced by threaded reinforcing bar ends and threaded coupler, or by sleeves hydraulically pressed or forged onto butt-ended reinforcing bars, or by other proprietary mechanical splicing method as proposed by the Contractor and approved by the Engineer. Mechanical splice couplers shall be capable of being installed in the clear space indicated and to provide the required clearances.

2. Spliced Strength in Tension: Minimum 125 percent of the yield strength of connected reinforcing bars, unless otherwise indicated.

2.02 FABRICATION

A. Fabrication Standards: Fabrication of steel reinforcement shall be in accordance with the Contract Drawings and approved Shop Drawings. Where specific details are not indicated, comply with applicable requirements of ACI 301, ACI 318, and CRSI Manual of Standard Practice.

B. Cutting and Bending: Cutting and bending shall be performed at a central location, equipped and suitable for the purpose. Bars shall be accurately cut and bent as indicated. Bars shall be bent cold prior to placement. Field bending of reinforcement partially embedded in concrete shall not be permitted. Heating of bars for bending or straightening is not permitted. Bars shall not be bent or straightened in any manner that damages the material. Label bars in accordance with bending diagrams and schedules, and secure like pieces in bundles when appropriate.

C. Welding:

1. Welding of reinforcement, where indicated and approved, including preparation of bars, shall conform with applicable requirements of AWS D1.4/D1.4M. Welders shall be prequalified in accordance with AWS D1.4/D1.4M, Chapter 6.

2. Use full penetration butt welds by the electric-arc method unless otherwise indicated or approved. Weld splices shall develop 125 percent of the specified yield strength of the bars, or of the smaller bar in transition splices.

3. Clean bars of oil, grease, dirt, and other foreign matter and flame-dry before welding. Preheat bars before welding in accordance with AWS D1.4/D1.4M, Chapter 7. Stagger splices in adjacent bars a minimum of 48 inches.

D. Repair of Damaged Coatings: Bars for galvanized reinforcement shall be cut and bent cold before galvanizing. Galvanized and epoxy coatings damaged by shipping, handling, or cutting and bending shall be repaired as specified in ACI 301, and ASTM A767/A767M, ASTM A775/A775M, ASTM A884/A884M, and ASTM D3963/D3963M, as applicable.

2.03 IDENTIFICATION

A. Reinforcing steel shall be bundled and tagged with grades and sizes, heat numbers, and suitable identification marks for checking, sorting, and placing. Sizes and mark numbers shall correspond to placing Shop Drawings and schedules. Tags and markings shall be water-resistant and shall not be removed until steel reinforcement is placed in position.

2.04 REINFORCING STEEL FOR DUCT BANKS

A. Reinforcing steel shall be provided for duct banks. Longitudinal steel shall be provided with a minimum total cross sectional area of 0.0018 times the gross area of the duct bank. The maximum spacing of reinforcing bars shall be 18 inches, with a minimum of one bar provided in each corner. Tie bars in the transverse direction enclosing the longitudinal steel bars shall also be provided, with a minimum size of No. 3 bars at a minimum spacing of 12 inches. The minimum clear concrete cover over reinforcing steel shall be 3 inches where concrete is cast directly against earth, and 1-1/2 inches where concrete is cast directly against fabricated formwork.

B. Where duct banks enter rigid underground structures, reinforcing steel shall be provided to tie the duct bank to the structure. Prevent damage to duct banks due to differential settlement at these points using methods provided by the Engineer.

PART 3 – EXECUTION

3.01 VERIFICATION OF CONDITIONS

A. Verify that surfaces, over or against which concrete is to be placed, are clean and in proper condition for placing reinforcement.

B. Verify that items to be embedded in concrete inserts, sleeves, and block-outs are secured in place as required.

3.02 PLACING

A. Placing Standards: Reinforcing steel shall be placed in accordance with the Contract Drawings, approved Shop Drawings, and the applicable requirements of ACI 301, ACI 318, ACI 117, CRSI Manual of Standard Practice, and CRSI Placing Reinforcing Bars. Install reinforcement accurately and secure against movement, particularly under the weight of workers and the placement of concrete.

B. Reinforcing Supports: Bars shall be supported on metal or plastic chairs, spacers, and hangers, accurately placed and securely fastened to steel reinforcement in place. Support legs of accessories in forms without embedding in the form surface. Hoops and stirrups shall be accurately spaced and wired to the reinforcement.

C. Placing and Tying: Reinforcing steel shall be installed in place, spaced, and securely tied or wired with tie wire at all splices and at crossing points and intersections in the positions indicated. Comply with requirements of CRSI Placing Reinforcing Bars, Chapter 10. Welding to secure or support rebar replacement is prohibited. Snap ties are acceptable for intermediate intersections. Rebending of bars on the job to fit different conditions will not be permitted. Point ends of wire ties away from adjacent form surfaces.

D. Spacing: Center-to-center distance between parallel bars shall be in accordance with the Contract Drawings or, where not indicated, the minimum clear spacing shall be in accordance with ACI 318.

E. Longitudinal Location of Bends and Ends of Bar: A maximum of plus or minus 2 inches from the indicated location shall be permitted, provided that specified protective concrete cover at ends of members is not reduced by more than 1/2 inch. At a discontinuous end of a structural member, the tolerance shall be plus or minus 1 inch. At the discontinuous ends of corbels and brackets, the tolerance shall be plus or minus 1/2 inch.

F. Splices:

1. Lapped Splices:

    a. Laps of splices shall be securely tied together to maintain the alignment of the bars, to provide the required minimum clearances, and to transfer stress by bond. Lapped splices and development lengths not shown shall be detailed to develop Class B lapping lengths and development lengths in tension, respectively, in accordance with ACI 318.

    b. Splices of alternate bars shall be staggered a minimum clear offset of 2 feet between splices. Splices shall be tied with tie wire, or splices may be lap welded in accordance with AWS D1.4/D1.4M. Lapped splices are not permitted for No. 14 and No. 18 bars, or when specifically excluded by Contract provisions regardless of size.

2. Exothermic Metal-Filled Coupler Splices: Conform with the product manufacturer’s installation instructions and recommendations and with applicable requirements of AWS D1.4/D1.4M for exothermic welding.

3. Mechanical Coupler Splices:

    a. Perform installation of coupler and tightening of joint assembly in accordance with the coupler manufacturer's installation instructions and recommendations.

    b. Reinforcing bars to be joined shall be shop threaded using special machinery to produce the required tapered threads. Where previously threaded bars must be cut or where threads are damaged, bars shall be replaced, or an alternate splicing system approved by the Engineer shall be substituted. Bars shall not be rethreaded, and damaged threads shall not be repaired in the field.

    c. Prior to joining, inspect all threads and assure that they have been properly made and are clean.

    d. Rotate coupler and bar initially by hand or wrench until snug (approximately 3-1/4 to 4 turns). Apply 24-inch minimum pipe wrench and turn coupler (or bar) until further turning is resisted with the application of a minimum torque of 200 foot-pounds. Suitably mark joint to indicate that tightening has been completed.

    e. For proprietary mechanical splicing systems not specified herein, installation shall conform with the manufacturer's installation instructions.

4. Spiral Reinforcement Splices: Splices shall conform with applicable requirements of ACI 318.

5. Splices in Tension Tie Members: Splices in tension tie members shall be made with a mechanical or welded splice. Splices in adjacent bars shall be staggered at least 30 inches.

6. Splice lengths of shell reinforcement shall be at least the greater of 1.3 l_d and 18 inches. Splices shall be staggered at least l_d with not more than one-third of the reinforcement spliced at any section, in which l_d is development length in tension of bar.

G. Dowels: Provide dowels where indicated or required for connecting construction and for maintaining structural and reinforcement continuity. Dowels shall be tied securely in place before concrete is deposited. Provide additional bars for proper support – and anchorage where required. Do not bend dowels after embedment.

H. Welded Wire Fabric:

1. Wire fabric shall be installed in lengths as long as practicable and shall be wire-tied at all laps and splices. End laps shall be offset in adjacent widths. Lap welded wire fabric in accordance with applicable requirements of ACI 318.

2. Where required welded wire fabric shall be secured in position with suitable supports, accessories, and tie wire as indicated and required to ensure against movement from workers and placement of concrete lift fabric as concrete is placed to assure proper embedment at position indicated.

3.03 PROTECTIVE CONCRETE COVER

A. Minimum concrete coverage for steel reinforcement shall be as specified in ACI 301, ACI 318, or CRSI Manual of Standard Practice. If there is a conflict between the standards specified, the thicker concrete coverage shall govern.

3.04 CLEANING:

A. Reinforcement at time of depositing concrete shall be free of corrosion and coatings that may impair bond with concrete, such as form oil, mill scale, or loose deposits of rust and other corrosion.

3.05 FIELD QUALITY CONTROL

A. In accordance with Section 01 45 00, Quality Control, quality control inspections and tests to be performed by the Contractor include the following:

1. Placement of Reinforcing Steel: Visual inspection of reinforcing steel in place, including bar supports, tied laps and intersections, welded wire fabric, and bar mats.

2. Welds:

    a. Visual inspection of reinforcing bar welds.

    b. Tension tests of welded butt joints. Tests shall be performed on sample welds produced by the Contractor in accordance with ASTM E8/E8M.

    c. Nondestructive tests of installed welded butt joints shall be performed in accordance with ASTM E165/E165M.

    d. Inspections and tests shall be performed in accordance with the applicable requirements of AWS D1.4/D1.4M, Chapters 8 and 9.

3. Exothermic/Coupler Splices:

    a. Continuous visual inspection for the first eight hours, minimum, of the work as performed by any crew, and again by any replacement crew. All splices require visual inspection before concrete may be placed.

    b. Visual inspection shall be performed in accordance with the product manufacturer’s instructions and recommendations for such inspection.

    c. Inspections shall measure and record all voids. Exothermic rebar splices shall be accepted, provided measured “void limits,” per end, do not exceed manufacturer’s specified “void limits.”

    d. Splices indicating improper fill, slag at tap hole, or blowouts shall be rejected.

4. Mechanical Coupler Splices: Test 100 percent of the couplers, using a 24-inch click-type torque wrench calibrated to 200 foot-pounds. Minimum turning torque of 200 foot-pounds shall be applied to the extent that further turning is resisted.

Where tests reveal failure of couplers to be properly tightened, couplers shall be removed and replaced.

B. For exothermic/coupler splices, the Contractor shall provide qualification splices for each position as follows:

1. One sister splice for the first 25 splices; thereafter, one sister splice for every 50 splices.

2. Sister splices shall be laboratory tested by the Engineer for strength in tension (125 percent of the yield strength of connecting bars).

END OF SECTION 03 20 00

SECTION 03 30 00

CAST-IN-PLACE CONCRETE

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Conveying and placing concrete.

B. Placement under water.

C. Consolidation.

D. Construction joints.

E. Expansion and contraction joints.

F. Curing and protection.

1.02 RELATED SECTIONS

A. Portland cement concrete specified in Section 03 05 15, Portland Cement Concrete.

B. Finishing and curing of formed and unformed concrete surfaces, including repair and patching of surface defects, are specified in Section 03 35 00, Concrete Finishing.

C. Shotcrete is specified in Section 03 37 13, Shotcrete.

D. Vapor barrier under slabs on grade is specified in Section 07 26 00, Vapor Retarders.

E. Formwork is specified in Section 03 11 00, Concrete Forming.

F. Joint fillers and sealers are specified in Section 03 15 00, Concrete Accessories.

G. Waterstops are specified in Section 03 15 13, Waterstops.

H. Reinforcing steel is specified in Section 03 20 00, Concrete Reinforcing.

1.03 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for cast-in-place concrete will be either by the lump-sum method or by the unit-price method as determined by the listing of the bid item for cast-in-place concrete indicated in the Bid Schedule of the Bid Form.

B. Lump Sum: If the Bid Schedule indicates a lump-sum for cast-in-place concrete, the lump-sum method of measurement and payment will be in accordance with Section 01 20 00, Price and Payment Procedures, Article 1.02.

C. Unit Prices: If the Bid Schedule indicates a unit price for cast-in-place concrete, the unit-price method of measurement and payment will be as follows:

1. Measurement:

   a. Except as specified otherwise in other Sections of these Specifications or the Contract Specifications, each class of concrete and type of placement of cast-in-place concrete will be measured for payment by the cubic yard, and quantities will be computed, based on the neat lines or pay lines, section profiles, and dimensions indicated on the Contract Drawings, without deduction for chamfers, reinforcing steel and embedded items, and openings and recesses having an area of less than two square feet.

   b. Additional concrete used to replace overcut or for overbreak, or to repair or replace defective work, will not be measured separately for payment.

2. Payment: Cast-in-place concrete will be paid for at the indicated Contract unit prices for the computed quantities as determined by the measurement method specified in Article 1.03.C.1.

1.04 REFERENCES

A. American Concrete Institute (ACI):

1. ACI 117 Specification for Tolerances for Concrete Construction and Materials and Commentary
2. ACI 301 Specifications for Structural Concrete
3. ACI 302.1R Guide for Concrete Floor and Slab Construction
4. ACI 304R Guide for Measuring, Mixing, Transporting, and Placing Concrete
5. ACI 304.2R Placing Concrete by Pumping Methods
6. ACI 305R Guide to Hot Weather Concreting
7. ACI 306.1 Standard Specification for Cold Weather Concreting
8. ACI 308R Guide to External Curing of Concrete
9. ACI 309R Guide for Consolidation of Concrete
10. ACI 318 Building Code Requirements for Structural Concrete and Commentary
11. ACI 548.13 Specification for Bonding Fresh Concrete to Hardened Concrete with a Multi-Component Epoxy Adhesive

B. American Society for Testing and Materials (ASTM):

1. ASTM C31/ C31M — Standard Practice of Making and Curing Concrete Test Specimens in the Field

2. ASTM C94/ C94M — Standard Specification for Ready-Mixed Concrete

3. ASTM C881/ C881M — Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings:

1. Submit drawings that indicate the locations of all joints in concrete, including construction joints, expansion joints, isolation joints, and contraction joints. Coordinate with the requirements specified in Section 03 11 00, Concrete Forming.

2. Submit drawings that indicate concrete placement schedule, method, sequence, location, and boundaries. Include each type and class of concrete, and quantity in cubic yards.

C. Product Data: Submit manufacturer’s product data for epoxy adhesive.

D. Records and Reports: Report the location in the finished work of each mix design, and the start and completion times of placement of each batch of concrete placed for each date concrete is placed.

1.06 QUALITY CONTROL

A. Tolerances:

1. Concrete Tolerances: Comply with the requirements of ACI 117 as applicable. Coordinate with the requirements specified in Section 03 11 00, Concrete Forming.

2. Tolerances for Slabs and Flatwork: Comply with the requirements specified in Section 03 35 00, Concrete Finishing.

B. Architectural Concrete: Where concrete is indicated as architectural concrete exposed to public view, such concrete shall be produced in accordance with applicable requirements of ACI 301.

C. Site Mock-Ups:

1. Refer to Section 01 43 38, Field Samples and Mockups, for mock-up requirements and procedures.

2. Construct site mock-ups for all architectural concrete work and formed concrete that will be exposed to the public in the finished work, not less than four feet by six feet in surface area, for review and acceptance by the Engineer, before starting the placement of concrete.

3. Approved site mock-ups shall set the standard for the various architectural concrete features, formed finishes, and colors of the concrete. Provide as many mock-ups as required to show all the different features and formed surfaces of the concrete.

D. Cold Joints: Cold joints in concrete will not be permitted unless planned and treated properly as construction joints.

E. Monitoring of Formwork: Provide monitoring of forms and embedded items to detect movement, or forms and embedded items out-of-alignment, from pressure of concrete placement.

1.07 ENVIRONMENTAL REQUIREMENTS

A. Delivering and placing of concrete in hot weather and cold weather shall conform with applicable requirements of ACI 305R and ACI 306.1 and Section 03 05 15, Portland Cement Concrete.

B. Do not place concrete when the rate of evaporation of surface moisture from concrete exceeds 0.2 pounds per square foot per hour as indicated in ACI 305R.

C. Do not place concrete in, or adjacent to, any structure where piles are required until all piles in the structure have been driven or installed.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Formwork: Refer to Section 03 11 00, Concrete Forming, for requirements.

B. Joint Fillers and Sealers: Refer to Section 03 15 00, Concrete Accessories, for requirements.

C. Waterstops: Refer to Section 03 15 13, Waterstops, for requirements.

D. Reinforcing Steel: Refer to Section 03 20 00, Concrete Reinforcing, for requirements.

E. Portland Cement Concrete: Refer to Section 03 05 15, Portland Cement Concrete, for mix designs and other requirements.

F. Concrete Curing Materials: Refer to Section 03 35 00, Concrete Finishing, for requirements.

G. Vapor Barrier Materials: Refer to Section 07 26 00, Vapor Retarders, for requirements.

H. Epoxy Adhesive: ASTM C881/C881M, Type II for non-load-bearing concrete and Type V for load-bearing concrete, Grade and Class as determined by project conditions and requirements.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Inspect forms, earth bearing surfaces, reinforcement, and embedded items, and obtain the Engineer's written approval before placing concrete. Complete and sign a pour card on the form supplied by the Engineer. The Engineer shall countersign the card prior to commencing the pour.

3.02 PREPARATION

A. Place concrete under the observation of the Engineer and with the Contractor's Quality Control Representative present to document requirements and results of the placement.

B. Whenever possible, place concrete during normal working hours. When concrete--placement schedules require concrete placement at times other than normal working hours, ensure that the Engineer is notified and is present at the time of placement.

C. Do not place concrete until conditions and facilities for the storage, handling, and transportation of concrete test specimens are in compliance with the requirements of ASTM C31/C31M and Section 03 05 15, Portland Cement Concrete, and are approved by the Engineer.

D. Prior to placement of concrete, the subgrade shall be in a firm, well-drained condition, and of adequate and uniform load-bearing nature to support construction personnel, construction materials, construction equipment, and steel reinforcing mats without tracking, rutting, heaving, or settlement. All weak, soft, saturated, or otherwise unsuitable material shall be removed and replaced with structural backfill or lean concrete.

E. All structure foundations, including those for Stations and for subway box, shall be inspected and approved, in writing, by a qualified, independent geotechnical engineer prior to placement of footings and base slabs, to confirm the adequacy of the supporting soil for concrete placement.

F. Earth bottoms or bearing surfaces for footings and slabs shall be dampened but not saturated or muddied just before placing concrete.

3.03 TRANSPORTING

A. Concrete shall be central-mixed concrete from a central batch plant, transported to the jobsite in a truck mixer, in accordance with the requirements specified in Section 03 05 15, Portland Cement Concrete, and ASTM C94/C94M.

B. Transport concrete to the jobsite in a manner that will assure efficient delivery of concrete to the point of placement without adversely altering specified properties with regard to water-cement ratio, slump, air entrainment, and homogeneity.

3.04 CONVEYING AND PLACING

A. Placement Standards: Conveying and placing of concrete shall conform with applicable requirements of ACI 301, ACI 302.1R, ACI 304R, and ACI 318.

B. Handling and Depositing:

1. Concrete placing equipment shall have sufficient capacity to provide a placement rate that will preclude cold joints and that shall deposit the concrete without segregation or loss of ingredients.

2. Concrete placement, once started, shall be carried on as a continuous operation until the section of approved size and shape is completed.

3. Concrete shall be handled as rapidly as practicable from the mixer to the place of final deposit by methods that prevent the separation or loss of ingredients. Concrete shall be deposited, as nearly as practicable, in its final horizontal position to avoid redistribution or flowing.

4. Concrete shall not be dropped freely where reinforcing will cause segregation, nor shall it be dropped freely more than 5 feet. Concrete shall be deposited to maintain a plastic surface approximately horizontal.

5. In placing walls, columns, or thin sections (6 inches or less in thickness) of heights greater than 10 feet, concrete placement rate, lift thickness, and time intervals between lifts shall be as indicated on approved Shop Drawings. Openings in the form, elephant trunk tremies, or other approved devices, shall be used that will permit the concrete to be placed without segregation or accumulation of hardened concrete on the forms or metal reinforcement above the level of the fresh concrete.

6. Concrete that has partially hardened shall not be deposited in the work. The discharge of concrete shall be started not later than 60 minutes after the introduction of mixing water. Placing of concrete shall be completed within 90 minutes after the first introduction of water into the mix.

C. Pumping:

1. Concrete may be placed by pumping if the maximum slump can be maintained and if accepted in writing by the Engineer for the location proposed.

2. Placing concrete by pumping methods shall conform with applicable requirements of ACI 304R and ACI 304.2R.

3. Equipment for pumping shall be of such size and design as to ensure a continuous flow of concrete at the delivery end without separation of materials. Concrete from end of hose shall have a free fall of less than 5 feet. Pump hoses shall be supported on horses or similar devices so that reinforcement or post-tensioning ducts or tendons are not moved from their original position.

4. The concrete mix shall be designed to the same requirements as specified in Section 03 05 15, Portland Cement Concrete, and may be altered for placement purposes with the prior approval of the Engineer.

3.05 PLACEMENT UNDER WATER

A. Placement Standards: Placing of concrete in or under water shall conform with requirements of ACI 304R. All concrete to be placed under water shall be placed by the tremie method or by direct pumping.

B. Placement Requirements: Deposit concrete in water only when indicated or approved in writing by the Engineer, and only under the observation of the Engineer. Use only tremie method and direct pumping with equipment that has been accepted by the Engineer.

3.06 CONSOLIDATION

A. Concrete shall be thoroughly consolidated and compacted by mechanical vibration during placement in accordance with the requirements of ACI 309R.

B. The Engineer will inspect concrete placement to confirm that proper placing methods are being employed, and that special techniques are being used in congested areas and around obstructions such as pipes and other embedded items. Check installation of embedded items for correct location and orientation during concrete placement.

C. Conduct vibration in a systematic manner by competent, skilled, and experienced workers, with regularly maintained vibrators, and with sufficient back-up units at the jobsite. Use the largest and most powerful vibrator that can be effectively operated in the given work, with a minimum frequency of 8,000 vibrations or impulses per minute, and of sufficient amplitude to effectively consolidate the concrete.

D. Insert and withdraw the vibrator vertically at uniform spacing over the entire area of the placement. Space the distance between insertions such that “spheres of influence” of each insertion overlap.

E. Conduct vibration so as to produce concrete that is of uniform texture and appearance, free of honeycombing, air and rock pockets, streaking, cold joints, and visible lift lines.

F. On vertical surfaces and on all architectural concrete where an as-cast finish is required, use additional vibration and spading as required to bring a full surface of mortar against the forms, so as to eliminate objectionable air voids, bug holes, and other surface defects. Additional procedures for vibrating concrete shall consist of the following:

1. Reduce the distance between internal vibration insertions and increase the time for each insertion.

2. Insert the vibrator as close to the face of the form as possible, without contacting the form.

3. Use spading as a supplement to vibration at forms to provide fully filled out form surfaces without air holes and rock pockets.

4. Provide vibration of forms only if approved by the Engineer for the location.

3.07 CONSTRUCTION JOINTS

A. Construction joints will be permitted only where indicated or approved by the Engineer.

B. Provide and prepare construction joints and install waterstops in accordance with the applicable requirements of ACI 301 and ACI 304R, and as specified in Section 03 11 00, Concrete Forming.

C. Make construction joints straight and as inconspicuous as possible, and in exact vertical and horizontal alignment with the structure, as the case may be.

D. Use approved key, at least 1-1/2 inches in depth, at joints unless otherwise indicated or approved by the Engineer.

E. Thoroughly clean the surface of the concrete at construction joints and remove laitance, loose or defective concrete, coatings, sand, sealing compound and other foreign material. Prepare surfaces of joints by sandblasting or other approved methods to remove laitance and expose aggregate uniformly.

F. Immediately before new concrete is placed, wet the joint surfaces and remove standing water. To allow for shrinkage, do not place new concrete against the hardened concrete side of a construction joint for a minimum of 72 hours.

G. Locate joints that are not indicated so that the strength of the structure is not impaired. Joint types and their locations are subject to prior approval of the Engineer.

H. Ensure that reinforcement is continuous across construction joints.

I. Place waterstops in construction joints where indicated.

J. Where bonding of the joint is required, provide epoxy adhesive hereinbefore specified and apply in accordance with ACI 548.13.

K. Retighten forms and dampen concrete surfaces before concrete placing is continued.

L. Allow at least 72 hours to elapse before continuing concrete placement at a construction joint. Approval for accelerating the minimum time elapsing between adjacent placements will be based on tests and methods that confirm that a minimum moisture loss at a relatively constant temperature will be maintained for the period as necessary to control the heat of hydration and hardening of concrete, and to prevent shrinkage and thermal cracking.

3.08 EXPANSION AND CONTRACTION JOINTS

A. Refer to Section 03 11 00, Concrete Forming, for slab screeds and for formwork where expansion and contraction joints are indicated as architectural features, such as reveals or rustications.

B. Refer to Section 03 15 00, Concrete Accessories, for expansion joint filler material and joint sealing compound.

C. Refer to Section 03 35 00, Concrete Finishing, for finishing of edges of expansion joints in slabs with curved edging tool.

3.09 CURING AND PROTECTION

A. Curing of concrete shall conform with applicable requirements of ACI 301 and ACI 308R, except that the curing duration shall be a minimum period of ten Days. HVFAC shall be cured a minimum of 28 Days including an initial 10 Days of moist curing. Curing with earth, sand, sawdust, straw, and hay will not be permitted.

B. Keep concrete in a moist condition from the time it is placed until it has cured for at least ten Days. Keep forms damp and cool until removal of forms.

C. Immediately upon removal of forms, exposed concrete surfaces shall be kept moist by applying an approved curing compound or by covering with damp curing materials as specified in Section 03 35 00, Concrete Finishing.

D. Concrete shall not be permitted to dry during the curing period because of finishing operations.

E. Protect fresh concrete from hot sun, drying winds, rain, damage, or soiling. Fog spray freshly placed slabs after bleed water dissipates and after finishing operations commence. Allow no slabs to become dry at any time until finishing operations are complete.

F. Finishing and curing of slabs are specified in Section 03 35 00, Concrete Finishing.

G. Protect concrete from injurious action of the elements and defacement of any kind. Protect exposed concrete corners from traffic or use that will damage them in any way.

H. Protect concrete during the curing period from mechanical and physical stresses that may be caused by heavy equipment movement, subjecting the concrete to load stress, load shock, or excessive vibration.

3.10 REPAIR OF SURFACE DEFECTS

A. Refer to Section 03 35 00, Concrete Finishing, for requirements.

END OF SECTION 03 30 00

SECTION 03 35 00

CONCRETE FINISHING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Repair of surface defects.

B. Finishing of formed surfaces.

C. Slabs and flatwork.

D. Curing.

1.02 RELATED SECTIONS

A. Concrete formwork is specified in Section 03 11 00, Concrete Forming.

B. Cast-in-place concrete is specified in Section 03 30 00, Cast-In-Place Concrete.

C. Concrete topping slabs for station concourse and platforms are specified in Section 03 53 00, Concrete Topping.

1.03 MEASUREMENT AND PAYMENT

A. Measurement: Repair of surface defects, finishing, and curing of concrete will not be measured separately for payment.

B. Payment: Repair of surface defects, finishing, and curing of concrete will be paid for as part of the indicated Contract unit prices or lump-sum prices for the associated concrete work as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):

1. AASHTO M182 Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats

B. American Concrete Institute (ACI):

1. ACI 117 Specification for Tolerances for Concrete Construction and Materials and Commentary

2. ACI 301 Specifications for Structural Concrete

3. ACI 308R Guide to External Curing of Concrete

4. ACI 503.4 Standard Specification for Repairing Concrete with Epoxy Mortars

C. American Society for Testing and Materials (ASTM):

1. ASTM C33/ C33M Standard Specification for Concrete Aggregates
2. ASTM C150/ C150M Standard Specification for Portland Cement
3. ASTM C171 Standard Specifications for Sheet Materials for Curing Concrete
4. ASTM C309 Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
5. ASTM C881/ C881M Standard Specification for Epoxy-Resin-Base Bonding System for Concrete
6. ASTM E1155 Standard Test Method for Determining FF Floor Flatness and FL Floor Levelness Numbers

D. State of California, Department of Transportation (Caltrans), Standard Specifications:

1. Section 51 Concrete Structures

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures. Submittals involving exposed concrete finishes require approval of the Engineer before they may be incorporated in the Work.

B. Shop Drawings: Submit drawings, or diagrams to scale, that indicate the location in plan and elevation of all concrete finishes.

C. Product Data: Submit manufacturers' product data for manufactured products.

D. Samples:

1. Submit 1/2-pint sample container of aluminum oxide and silicon carbide abrasive grit for review and acceptance where "non-slip finish" is indicated.
2. Submit samples not less than 12 inches by 12 inches in size of each type of sand blast finish, indicating materials and methods used to produce the sand blast finishes. Review by the Engineer will be for color and texture only. Approved samples will become the Engineer's control samples.

1.06 QUALITY ASSURANCE

A. Finishes:

1. Finishing of formed concrete surfaces shall conform to applicable requirements of ACI 301.

2. Finishes for slabs and flatwork shall conform to applicable requirements of ACI 301.

3. Special architectural finishes for formed concrete surfaces shall conform with applicable requirements of ACI 301.

4. Bridge deck finishes shall conform to applicable requirements of Caltrans Standard Specifications Section 51.

B. Curing: Conform to requirements of ACI 301 and ACI 308R, as applicable, and requirements specified herein.

C. Site Mock-Ups: Provide site mock-ups, at least 3 feet by 4 feet in size, of finishes of formed surfaces in exposed locations and of exposed slab finishes for the Engineer's review and approval. Refer to Section 01 43 38, Field Samples and Mock-ups, for requirements and procedures.

D. Site Mock-ups of Architectural Concrete: Provide site mock-ups of architectural concrete showing finish texture and pattern of exposed formed concrete surfaces.

1. Size of mock-up shall be a minimum of 8 feet by 10 feet, unless otherwise approved by the Engineer to be smaller.

2. The number of mock-up panels required shall be the number necessary to obtain the Engineer's approval of pattern and texture of panel.

3. Approved mock-up shall be used as the standard for the aesthetic quality of the surface finish of architectural concrete.

E. Requirements of Regulatory Agencies: Comply with air pollution regulations of governing authorities for sand-blasting activities and operations.

PART 2 – PRODUCTS

2.01 TOOLS AND EQUIPMENT:

A. The Contractor shall furnish all materials, tools, equipment, facilities, and services as required for performing the required concrete-finishing work.

2.02 REPAIR AND FINISHING MATERIALS

A. Portland Cement: ASTM C150/C150M, Type II, of same brand as used in the work. Furnish white portland cement where required to produce color matching color of surrounding concrete.

B. Aggregate:

1. For Bonding Grout: ASTM C33/C33M, washed clean sand passing a No. 30 sieve.

2. For Patching Mortar: ASTM C33/C33M, washed clean, graded fine aggregate of suitable size for areas to be repaired. Clean coarse aggregate up to Size No. 8 may be added for repair of larger pockets and voids.

C. Commercial Patching Mortar: A structural repair mortar may be furnished if appropriate for the use and approved by the Engineer.

D. Epoxy Patching Mortar: As specified in ACI 503.4 for Epoxy Mortar.

E. Epoxy Adhesive: ASTM C881/C881M, Type II or Type V, epoxy-based bonding agent.

F. Anti-Slip Abrasive Grit: Virgin grain Aluminum Oxide or Silicon Carbide particles, or a mixture of the two.

2.03 CURING MATERIALS

A. Damp Curing Materials:

1. Waterproof Sheet Materials: ASTM C171, waterproof paper with white paper face, polyethylene film pigmented white, or white burlap-polyethylene sheeting.

2. Burlap: AASHTO M182, of class or weight suitable for the use and location. Do not use burlap where concrete is exposed to direct sunlight.

B. Curing Compound: ASTM C309, liquid membrane-forming curing compound, Type 1, Class A or B as appropriate for the use or location.

1. Where concrete surfaces will receive architectural finishes, such as resilient floor coverings or paint, or membrane waterproofing, membrane-forming curing compound shall not leave a coating or residue that will impair bond of adhesives, paints, and coatings with concrete.

PART 3 – EXECUTION

3.01 REPAIR OF SURFACE DEFECTS

A. Repair Standards: Repair of surface defects shall conform with applicable requirements of ACI 301. When using epoxy mortar, conform with applicable requirements of ACI 503.4.

B. Surface Defects:

1. Repair of surface defects shall begin immediately after form removal. For repair with epoxy mortar, concrete shall be dry.

2. Surface defects are defined to include: form-tie holes, air voids or pockets, bug holes with a nominal diameter or depth greater than 1/4-inch, honeycombed areas, rock pockets, visible construction joints, fins and burrs.

3. Repair of surface defects shall be tightly bonded and shall result in concrete surfaces of uniform color and texture, matching adjacent surfaces, and free of shrinkage cracks.

C. Repair Work:

1. Remove honeycombed and other defective concrete down to sound concrete. Saw-cut the edges perpendicular to the surface or slightly undercut. Feather-edges will not be permitted. Dampen the area to be patched and an area at least 6 inches wide surrounding it to prevent absorption of water from the patching mortar.

2. Where rock pockets or similar defects or voids expose steel reinforcement, cutout to solid surface behind the reinforcing steel to provide suitable key-lock for patching mortar. Patching mortar shall envelope the exposed reinforcing bar.

3. Bond patching mortar to concrete with bonding grout or epoxy adhesive. Bonding grout shall consist of 1 part portland cement to 1 part No. 30 mesh sand, mixed to the consistency of a thick cream, and then well brushed onto the concrete. Bond commercial patching mortar to concrete in accordance with the manufacturer’s instructions.

4. Make the patching mortar of the same materials and of approximately the same proportions as used for the concrete, except omit the coarse aggregate. Use not more than 1 part portland cement to 2-1/2 parts sand by damp loose volume, and substitute white portland cement for a portion of the regular gray portland cement to produce patching mix matching the surrounding concrete in color when dry. Determine the proportion of white portland cement by trial mixes and test areas, prior to repair of actual defective areas.

5. After surface water has evaporated from the area to be patched, brush the bond coat well into the surface. When the bond coat begins to lose the water sheen, apply the patching mortar. Compact the mortar into place and strike off so as to leave the patch slightly higher than the surrounding surface. To permit initial

shrinkage, leave the patch undisturbed for at least one hour before being finally finished. Keep the patched area damp for 7 Days.

6. Neatly finish patched surfaces to match adjacent surrounding surface texture of concrete. Grind or fill surfaces to produce level and plumb, true planes.

7. For walls exposed in the finish work, form tie holes shall be patched and finished flush with adjacent surface. For holes passing entirely through walls, a plunger type injection gun or other suitable device shall be used to completely fill the holes.

8. Patching of honeycombed areas or rock pockets that are too large and unsatisfactory for mortar patching shall be cut out to solid surface, keyed, and packed solid with matching concrete to produce firm bond and flush surface. Patching shall match texture of adjacent surfaces where exposed in the finished work.

9. Repair work in exposed locations that does not match the texture and color of surrounding adjacent surfaces or that was not well performed shall be removed and performed again until the repair work conforms with Specification requirements.

10. Surfaces to receive membrane waterproofing shall have fins and loose material removed, and voids and cracks patched flush with adjacent surfaces.

11. Completed repairs shall be cured as herein specified under Article 3.04, Curing.

3.02 FINISHING OF FORMED SURFACES

A. Unexposed Surfaces:

1. Concrete that will not be exposed in the completed structure shall be any form finish as specified in Section 03 11 00, Concrete Forming, and ACI 301 for “rough form finish.”

2. Concrete to receive membrane waterproofing shall receive a “smooth form finish” in accordance with ACI 301.

B. Exposed Surfaces: Unless indicated otherwise, concrete that will be exposed in the completed structure shall receive the following finishes as indicated:

1. Smooth Form Finish: Conform to ACI 301.

2. Smooth Rubbed Finish: Conform to ACI 301.

3. Grout Cleaned Finish: Conform to ACI 301.

4. Unspecified Finish: When finish is not indicated, provide “smooth form finish” as specified above.

C. Sand Blast Finish:

1. Blasting Operations and Requirements:

   a. Apply sandblasted finish to exposed concrete surfaces where indicated.

   b. Perform sand blasting at least 72 hours after placement of concrete. Coordinate with formwork construction, concrete placement schedule, and formwork removal to ensure that surfaces to be blast finished are blasted at the same age for uniform results.

   c. Determine type of nozzle, nozzle pressure, and blasting techniques required to match the Engineer's control samples.

   d. Abrasive blast corners and edge of patterns carefully, using back-up boards, to maintain uniform corner or edge line.

2. Depths of Cut: Use an abrasive grit of proper type and gradation to expose aggregate and surrounding matrix surface to match the Engineer's control samples as follows:

   a. Brush Sand Blast Finish: Remove cement matrix to expose face of fine aggregate; no reveal.

   b. Light Sand Blast Finish: Expose fine aggregate with occasional exposure of coarse aggregate; maximum 1/16-inch reveal.

   c. Medium Sand Blast Finish: Generally expose coarse aggregate; 3/16-inch to 1/4-inch reveal.

3. Surface Continuity: Perform sand blast finishing in as continuous an operation as possible, utilizing the same work crew to maintain continuity of finish on each surface or area of work. Maintain patterns of variances in depths of cuts as indicated.

4. Construction Joints: Use technique acceptable to the Engineer to achieve uniform treatment of construction joints.

5. Protection and Repair:

   a. Protect adjacent materials and finishes from dust, dirt, and other surface or physical damage during abrasive blast finishing operations. Provide protection as required and remove from site at completion of the work.

   b. Repair or replace other work damaged by finishing operations.

6. Clean-up: Maintain control of concrete chips, dust, and debris in each area of the work. Clean up and remove such material at the completion of each day of operation. Prevent migration of airborne materials by use of tarpaulins, wind breaks, and similar containing devices.

3.03 SLABS AND FLATWORK

A. Placement and Finishing Standards: Slabs and flatwork shall be placed, consolidated, and finished in accordance with applicable requirements of ACI 301. Coordinate with Section 03 30 00, Cast-In-Place Concrete, as applicable.

1. High volume fly ash concrete (HVFAC) exhibits little or no bleed water. Commence finishing as soon as power screeding is complete, and commence initial curing as soon as finishing has been completed.

B. Placement:

1. Slabs and flatwork shall be placed and finished monolithically. Strike off and screed slabs to true, plane surfaces at required elevations, and thoroughly compact concrete with vibrators, floats, and tampers to force coarse aggregate below the surface. Finish slab within four hours of concrete placement.

2. Whether indicated or not, in areas where drains occur, slope finished slab to drains. Slope shall be a minimum of 1/8-inch per foot unless otherwise indicated.

C. Slab Finishes: Unless indicated otherwise, slabs and flatwork shall receive the following finishes as indicated:

1. Scratched Finish: Conform to ACI 301. Provide “scratched finish” for slab substrates to receive cementitious toppings or finishes, such as terrazzo or mortar setting bed for ceramic tile.

2. Floated Finish: Conform to ACI 301. Provide “floated finish” for track slabs and mud slabs and for slabs and flatwork to receive roofing and membrane waterproofing.

3. Troweled Finish: Conform to ACI 301. Provide “troweled finish” for interior slabs and flatwork to be exposed in the completed structure, for slabs to receive resilient floor coverings, and for flatwork to receive elastomeric bearing pads.

4. Broom Finish: Conform to ACI 301. Exact texture and coarseness of the broom finish shall match the approved site mock-up. Provide fine or medium-coarse “broom finish” as indicated for exterior sidewalks and paving, exterior ramps, equipment and transformer pads, and subway invert slab.

5. Nonslip Finish: Conform to ACI 301. Nonslip materials shall be aluminum oxide and silicone carbide grit particles. Provide “nonslip finish” for interior pedestrian ramps, walkways, subway cross-passage floors, and other floor areas where indicated.

6. Swirl Pattern Finish: Provide for garage floors. After basic floating operations have been completed, hand float slabs using wood float to produce a continuous swirl patterned surface, free from porous spots, irregularities, depressions, and small pockets or rough spots such as may be caused by accidentally disturbing particles of coarse aggregate embedded near surface. Use natural arm circular motion to produce rows of approximately one-foot radius swirl pattern covering approximately half of the preceding row with each successive row.

7. Unspecified Finish: When finish is not indicated or specified, provide finishes as specified in ACI 301.

D. Surface Tolerances: As specified herein:

1. Flat Tolerance: Slabs and flatwork with “troweled finish” and with “nonslip finish.”

2. Straightedge Tolerance: Slabs and flatwork with fine “broom finish” or medium-coarse “broom finish.”

3. Bullfloated Tolerance: Slabs and flatwork with “scratched finish,” with “floated finish,” and with coarse “broom finish.”

E. Joints:

1. Construction, expansion, isolation, and contraction joints shall be located as indicated. Construction joints shall act as contraction joints. Where additional contraction joints are required to prevent shrinkage cracks, saw-cut such joints. All joints shall be straight and true to line. Saw-cut joints not less than twelve hours nor more than twenty-four hours after placing concrete, unless otherwise approved by the Engineer.

2. Mark-off lines or edges at formed construction and expansion joints shall be finished with 1/4-inch radius curved edging tool, neat and true to line, uniform throughout.

3.04 CURING

A. Curing Standards: Curing of concrete shall conform with applicable requirements of ACI 301 and ACI 308R, except that the duration of the curing period shall be 10 Days. Curing with earth, sand, sawdust, straw, and hay will not be permitted.

B. Curing Requirements:

1. Concrete shall be cured with waterproof sheet materials, damp burlap, or curing compounds.

2. Curing compounds shall not be used on top of ballasted aerial structures and on surfaces when their use may be detrimental to bonding of concrete, mortar, membrane waterproofing, calking and sealants, adhesives, plaster, paint, or the specified surface finish or coating.

C. Damp Curing:

1. Vertical surfaces shall be cured by keeping the forms wet at all times and by leaving the forms in place as long as possible as specified in Section 03 11 00, Concrete Forming. After removal of forms, concrete shall be kept continuously damp by fog spraying or otherwise washing down the concrete in an accepted manner until 10 Days after placing. Protect exposed surfaces by covering with sheet materials or burlap kept continuously moist.

2. Horizontal surfaces shall be cured and protected by covering the finished surfaces with waterproof sheet materials or damp burlap, left in place for a minimum of 10 Days and kept continuously moist.

3. Fog spray freshly placed slabs until finishing operations commence. Allow no slabs to become dry until finishing operations are complete.

D. Curing HVFAC: Initiate damp curing as soon as finishing has been completed. Damp cure for a minimum of 10 Days. Continue curing for a total of 28 Days. Curing after initial 10 Days may be by damp curing or using membrane-forming curing compound. Use evaporation reducer between finish operations, as necessary, to protect concrete from rapid drying

E. Curing Compound: Application of curing compound shall conform to applicable requirements of ACI 308R.

3.05 PROTECTION

A. Protect exposed concrete surfaces, including flatwork, as required to prevent damage from impact or strains.

B. Protect fresh concrete from drying winds, rain, damage, or soiling.

C. Refer to Section 03 30 00, Cast-In-Place Concrete, Article 3.09, for additional requirements.

3.06 TOLERANCES

A. Formed Surfaces: Conform with applicable requirements of ACI 117.

1. Where elastomeric bearing pads are indicated, the level plane upon which bearing pads are placed shall not vary more than 1/16-inch from a 10-foot straightedge placed in any direction across the area and the area shall extend a minimum of 1 inch beyond the limits of the pads.

2. Bearing surfaces of girders on a slope or girders with a camber shall be finished on a horizontal/level plane so that loads are uniformly distributed over the entire surface of the elastomeric bearing pads.

3. The finished plane shall not vary more than 1/8-inch from the elevation indicated.

B. Slabs and Flatwork: Conform to applicable classification requirements of ASTM E1155, as follows:

1. Very Flat Tolerance: F_F 50, F_L30. True plane with maximum variation of 1/8-inch in 10 feet when measured with a 10-foot straightedge placed anywhere on the slab in any direction.

2. Flat Tolerance: F_F 30, F_L20. True plane with maximum variation of 3/16-inch in 10 feet when measured with a 10-foot straightedge placed anywhere on the slab in any direction.

3. Straightedge Tolerance: F_F 20, F_L 15. True plane with maximum variation of 5/16-inch in 10 feet when measured with a 10-foot straightedge placed anywhere on the slab in any direction.

4. Bullfloated Tolerance: F_F 15, F_L 13. True plane with maximum variation of 1/2 inch in 10 feet when measured with a 10-foot straightedge placed anywhere on the slab in any direction.

END OF SECTION 03 35 00

SECTION 03 37 13

SHOTCRETE

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Preparation of substrate surfaces.

B. Shotcrete placement.

C. Curing.

1.02 RELATED SECTIONS

A. Reinforcing steel as specified in Section 03 20 00, Concrete Reinforcing.

B. Formwork as specified in Section 03 11 00, Concrete Forming.

C. Construction joints as specified in Section 03 30 00, Cast-In-Place Concrete.

1.03 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for shotcrete will be either by the lump-sum method or by the unit-price method as determined by the listing of the bid item for shotcrete indicated in the Bid Schedule of the Bid Form.

B. Lump Sum: If the Bid Schedule indicates a lump-sum for shotcrete, the lump-sum method of measurement and payment will be in accordance with Section 01 20 00, Price and Payment Procedures, Article 1.03.

C. Unit Price: If the Bid Schedule indicates a unit price for shotcrete, the unit-price method of measurement and payment will be as follows:

1. Measurement:

    a. Shotcrete will be measured for payment by the cubic yard of each mix placed in the work. The quantity for payment will be the actual or indicated square area placed multiplied by the thickness indicated on the Contract Drawings, unless a different thickness is approved by the Engineer.

    b. Reinforcing steel will be measured for payment by the pound as specified in Section 03 20 00, Concrete Reinforcing.

    c. Rebound will not be measured or included for payment.

2. Payment: shotcrete will be paid for at the indicated Contract unit prices for the computed quantities as determined by the measurement method specified in Article 1.03.C.1.

1.04 REFERENCES

A. American Concrete Institute (ACI):

1. ACI 506.2 Specifications for Shotcrete

B. American Society for Testing and Materials (ASTM):

1. ASTM C31/ C31M Standard Practice for Making and Curing Concrete Test Specimens in the Field
2. ASTM C33/ C33M Standard Specification for Concrete Aggregates
3. ASTM C42/ C42M Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
4. ASTM C94/ C94M Standard Specification for Ready-Mixed Concrete
5. ASTM C150/ C150M Standard Specification for Portland Cement
6. ASTM C494/ C494M Standard Specification for Chemical Admixtures for Concrete
7. ASTM C1604/ C1604M Standard Test Method for Obtaining and Testing Drilled Cores of Shotcrete
8. ASTM E329 Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection

1.05 DEFINITIONS

A. “Shotcrete” is defined as pneumatically placed concrete: A portland-cement concrete mixture conveyed through a hose and nozzle, and shot onto a surface at high speed by means of air pressure.

1.06 SUBMITTALS

A. Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Submittals shall include the following requirements:

1. Mix design;
2. Methods of application and equipment;
3. Certificates of compliance for materials;

4. Test results; and

5. Sample test panels.

1.07 QUALITY ASSURANCE

A. Shotcrete work shall be performed by a firm or company regularly engaged in the business of applying shotcrete materials, using nozzle operators and workers skilled and experienced in the type of work specified.

B. Shotcrete supervisor shall have not less than two years' experience as a shotcrete nozzle operator.

C. Nozzle operator shall have not less than one year experience and, upon request of the Engineer, shall demonstrate ability to properly place shotcrete.

1.08 ENVIRONMENTAL CONDITIONS

A. Shotcrete shall not be placed during inclement or windy weather.

B. Proper protective clothing shall be worn by operators, and any person in the area shall wear a mask during shotcreting until operations are stopped and the dust has cleared.

1.09 PROTECTION:

A. Protect adjacent surfaces from overspray and damage due to shotcreting operations. Prevent dust nuisance.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Portland Cement: ASTM C150/C150M, Type II. Type III cement may be used, subject to written approval of the Engineer.

B. Aggregate: ASTM C33/C33M normal weight aggregate with combined gradation of coarse and fine aggregates conforming to ACI 506.2, Gradation No. 1 or Gradation No. 2, as applicable to the work.

1. Maximum aggregate size may be varied, subject to acceptance by the Engineer.

2. Specific gravity of aggregate shall be not less than 2.50.

C. Water: Clean and potable, free of impurities detrimental to shotcrete.

D. Admixture: ASTM C494/C494M, Type C or Type E, containing no water-soluble chlorides or materials corrosive to steel or other properties that may cause cracking or spalling (for wet-mix shotcrete only.)

E. Ground Wires: No. 18 or 20 gage steel annealed wire.

F. Thickness Pins: Noncorrosive thickness-indication pins designed not to cause infiltration of water through shotcrete.

G. Reinforcing Steel: Comply with applicable requirements of Section 03 20 00, Concrete Reinforcing.

2.02 MIX DESIGN

A. Design of shotcrete mix, whether dry-mix shotcrete or wet-mix shotcrete, including recommended amounts of admixture and water to be used, shall be obtained by the Contractor from a qualified independent testing laboratory or agency, or from a mill or ready-mix plant, properly equipped to design shotcrete/concrete mixes. The laboratory, agency, mill or ready-mix plant shall meet the applicable requirements of ASTM E329, and shall meet with approval of the Engineer. The mix design shall be certified and signed by a professional engineer who is currently registered as a civil or structural engineer in the State of California. Costs of obtaining the mix design shall be paid for by the Contractor.

B. Shotcrete mix shall conform with the following requirements:

1. Proportion of cement to aggregate shall be as required to achieve the indicated or specified strength.

2. Water content at time of discharge from nozzle shall not exceed amount required to achieve the maximum permitted slump.

3. Compressive strength of shotcrete shall be not less than the indicated or specified 28-day compressive strength (pounds per square inch).

C. Upon receipt of acceptable shotcrete mix design and test results from the pre-approved independent testing laboratory, agency, mill, or ready-mix plant, conforming with specified requirements, the Contractor shall submit the accepted mix design to the Engineer for review prior to placing any shotcrete.

D. Shotcrete shall not be placed until the submitted mix design has been approved by the Engineer in writing.

2.03 EQUIPMENT AND MIXING

A. Equipment Standards: Equipment shall be appropriate and suitable for dry-mix or wet-mix shotcrete, as applicable, in accordance with the requirements of ACI 506.2.

B. Batching and Mixing Equipment: Materials shall be batched by weight and machine mixed, and delivered to the site pre-mixed. For wet-mix shotcrete, conform with the applicable requirements of ASTM C94/C94M for ready-mixed concrete.

C. Delivery Equipment: Conform with the applicable requirements of ACI 506.2. Equipment shall be capable of discharging mixture into delivery hose under close control and shall deliver a continuous stream of material at the proper volume to discharge nozzle. Discharge nozzle shall be equipped with a manually operated and adjustable air-injection system for directing an even distribution of air through the mixture. Nozzle shall deliver a conical discharge stream of uniform appearance. Equipment shall be cleaned daily and inspected for worn parts. Plaster guns are not permitted.

D. Air Supply: System shall employ a properly operating compressor of ample capacity to perform the work. Comply with capacity requirements specified in ACI 506.2, with modification for hose lengths and working heights.

PART 3 – EXECUTION

3.01 EXAMINATION OF SUBSTRATE SURFACES

A. Examine earth, rock, concrete, and masonry substrate surfaces, as applicable, and determine that such substrate surfaces have been properly prepared as hereinafter specified under Article 3.02.

B. Inspect soil anchors, if required by the Contract Specifications, and determine that they are of correct size and type, and properly located and installed.

C. Inspect reinforcing steel and determine that it is properly placed and tied, that sufficient clearances have been provided, and that it is free of grease, oil, loose rust, and other coatings that may impair bond with concrete.

D. Assure that sleeves and other items to be embedded in shotcrete are in place and that provisions for penetrations have been made.

E. Proceeding with shotcrete placement shall imply acceptance of substrate surfaces and conditions as satisfactory.

3.02 PREPARATION OF SUBSTRATE SURFACES

A. Prepare earth, rock, concrete, and masonry substrate surfaces, as applicable, in accordance with ACI 506.2.

B. Rock faces shall be free of loose rock.

C. Absorptive substrate surfaces shall be evenly dampened before placing shotcrete.

D. Formwork shall be designed and constructed to provide for escape of compressed air and rebound during shotcrete placement. Coordinate with Section 03 11 00, Concrete Forming.

E. Drain any free-standing water away from shotcrete operations.

F. Provide ground wires to establish thickness and surface planes. Install vertically and horizontally as required. Do not penetrate waterproof membranes.

G. As an alternative to ground wires, thickness measuring pins may be used to establish layer thickness and surface plane, provided such pins do not penetrate waterproof membranes and do not detrimentally damage substrates. Install pins on 5 foot centers in each direction.

3.03 SHOTCRETE PLACEMENT

A. Operation and Placement Standards: Shotcrete operations and placement shall conform with the applicable requirements of ACI 506.2.

B. Gunning/Nozzle Operation:

1. Build each layer by making several passes over the working area. Thickness of each layer shall be governed by the requirement that sagging of shotcrete shall not occur. Maintain top surface of thick layers at 45 degree slope. Each layer to be covered by a succeeding layer shall be allowed to take its initial set.

2. Laitance, loose material, and rebound shall be removed by air-jetting. Laitance that has taken a final set shall be removed by sandblasting and the surface cleaned with air-water jet. All layers to be shot shall be damp.

3. Unless otherwise permitted, begin application at the lowest elevation.

4. Do not trowel or finish initial layers in any way.

C. Rebound: Any rebound or accumulated loose aggregate shall be removed from the surface to be covered prior to placing succeeding layers. Rebound shall not be salvaged for reuse.

D. Construction Joints: Unfinished work shall not stand more than 30 minutes unless construction joints are provided for. Construction joints shall be designed and provided as specified in Section 03 30 00, Cast-In-Place Concrete. Entire joint surface shall be cleaned, roughened, and dampened prior to application of additional shotcrete.

E. Finishing: Bring shotcrete layers to within 1/4 inch of final finished surface. When surface has taken its initial set, trim excess material with a sharp edge cutting screed. Remove ground wires. Provide flash coat or finish coat as required for the final finish. Final finish shall be as specified in the Contract Specifications. Comply with applicable requirements of ACI 506.2.

3.04 CURING

A. Immediately following shotcrete finishing, surfaces shall be cured for not less than seven Days using an approved curing method as specified in ACI 506.2.

3.05 CLEANING

A. Clean surfaces and work site of rebound and waste materials, and remove from the site.

3.06 FIELD QUALITY CONTROL

A. Requirements: Conform with applicable requirements of Section 01 45 00, Quality Control. All tests, cores, and core tests shall be performed by an independent testing laboratory or agency employed by the Contractor at no additional cost to the District.

B. Inspections:

1. Visual inspection by the Engineer will be performed of the shotcrete work, including equipment, materials, forms, reinforcement, embedded items, placement, finishing, curing, and protection of the finished product.

2. Surfaces may be sounded with a hammer to locate drummy or hollow-sounding areas resulting from rebound pockets or lack of bond. Such hollow-sounding areas, voids, sags, and other defects shall be carefully cut out and replaced.

C. Quality Control Tests:

1. Test Panels:

a. From each 50 cubic yards of each shotcrete mix, or fraction thereof, applied in the work by each crew in each shooting position, fabricate four unreinforced test panels, each 18-inches square and 7-1/2 inches thick. Fabricate test panels in accordance with ACI 506.2. Properly cure test panels in accordance with ASTM C31/C31M and ACI 506.2.

b. Test panels will be visually examined by the Engineer, and shall be tested by an independent testing laboratory or agency employed by the Contractor at no additional cost to the District. Strength of shotcrete shall be considered acceptable when the average of all strength tests, as well as the average of three consecutive strength tests, representing each shotcrete mix is equal to at least 85 percent of the specified design strength and no individual strength test is less than 75 percent of the design strength. Strength tests shall be performed in accordance with ASTM C42/C42M.

c. The Engineer will require, at no additional expense to the District, adjustments to the mix proportions, requalification of the shotcreting crew, or additional curing of the shotcrete if either of the following conditions occur:

1) The average seven-day strength of any two specimens for the shotcrete mix is less than 70 percent of the specified 28-day strength, (three days for High-Early Strength Design); or

2) The average 28-day strength of any two specimens for the shotcrete mix is less than 100 percent of the specified 28-day strength.

2. Test Cores:

a. Should the test panels indicate that shotcrete not meeting the specified requirements has been produced, the Engineer will require tests of cores, taken from the areas represented by the test panels, to determine compliance of the in-place shotcrete with the specified requirements.

b. Test cores shall be 3 inches minimum diameters, obtained and tested in accordance with ASTM C1604/C1604M.

c. Three cores shall be taken for each determination of in-place strength. Shotcrete in the area represented by the core tests shall be considered structurally adequate if the average of the three cores is equal to at least 85 percent of the specified design strength and no single core is less than 75 percent of the design strength. Locations represented by erratic core strengths shall be ordered to be retested at the direction of the Engineer.

d. Fill core holes with low-slump concrete or mortar of same mix design as the placed shotcrete.

END OF SECTION 03 37 13

SECTION 03 40 00

PRECAST CONCRETE

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Reinforcing Steel.

B. Portland Cement Concrete.

C. Anchors, Lift Devices, and Accessories.

D. Stair Nosing.

E. Dielectric Insulation at Platform Edge.

F. Noise Abatement Seal.

1.02 RELATED SECTIONS

A. Precast concrete structures for utilities are specified in Section 33 05 16, Utility Structures.

B. Concrete formwork is specified in Section 03 11 00, Concrete Forming.

C. Reinforcing steel for concrete is specified in Section 03 20 00, Concrete Reinforcing.

D. Portland-cement concrete is specified in Section 03 05 15, Portland Cement Concrete.

E. Finishing of formed and unformed concrete surfaces, including repair of surface defects, are specified in Section 03 35 00, Concrete Finishing, except as specified otherwise herein.

F. Precast, prestressed concrete is specified in Section 03 05 18, Prestressed Concrete.

G. Steel supporting brackets and plates are specified in Section 05 50 00, Metal Fabrications.

H. Dielectric insulation membrane as specified in Section 07 13 19, Modified Sheet Waterproofing.

I. Sealant material and application as specified in Section 07 90 00, Joint Protection.

J. Touch-up paint as specified in Section 09 91 00, Painting.

1.03 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for precast concrete will be either by the lump-sum method or by the unit-price method as determined by the listing of the bid item for precast concrete indicated in the Bid Schedule of the Bid Form.

B. Lump Sum: If the Bid Schedule indicates a lump-sum for precast concrete, the lump-sum method of measurement and payment will be in accordance with Section 01 20 00, Price and Payment Procedures, Article 1.03.

C. Unit Prices: If the Bid Schedule indicates a unit price for precast concrete, the unit-price method of measurement and payment will be as follows:

1. Measurement:

   a. Precast concrete units will be measured for payment by the individual unit (each), erected and installed in place, multiplied by the total number of identical units installed.

   b. Each different type and size of precast concrete unit will be measured separately for payment.

   c. All other items specified in this Section will be considered incidental to precast concrete units and will not be measured separately for payment.

2. Payment: Precast concrete will be paid for at the indicated Contract unit prices for the computed quantities as determined by the measurement method specified in Article 1.03.C.1.

1.04 REFERENCES

A. American Concrete Institute (ACI):

1.	ACI 301	Specifications for Structural Concrete
2.	ACI 318	Building Code Requirements for Structural Concrete and Commentary

B. American Society for Testing and Materials (ASTM):

1.	ASTM A123/ A123M	Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
2.	ASTM A153/ A153M	Standards Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
3.	ASTM C31/ C31M	Standard Practice for Making and Curing Concrete Test Specimens in the Field
4.	ASTM C39/ ASTM C39M	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

5. ASTM C494/ C494M — Standard Specification for Chemical Admixtures for Concrete
6. ASTM C509 — Standard Specification for Elastomeric Cellular Preformed Gasket and Sealing Material
7. ASTM C542 — Standard Specification for Lock-Strip Gaskets
8. ASTM C618 — Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
9. ASTM C1017/ C1017M — Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete
10. ASTM D257 — Standard Test Methods for DC Resistance or Conductance of Insulating Materials
11. ASTM D638 — Standard Test Method for Tensile Properties of Plastics
12. ASTM D1622/ D1622M — Standard Test Method for Apparent Density of Rigid Cellular Plastics
13. ASTM D2240 — Standard Test Method for Rubber Property - Durometer Hardness

C. American Welding Society (AWS):

1. AWS D1.1/ D1.1M — Structural Welding Code – Steel
2. AWS D1.4/ D1.4M — Structural Welding Code - Reinforcing Steel

D. Precast/Prestressed Concrete Institute (PCI):

1. PCI MNL 117 — Manual for Quality Control for Plants and Production of Architectural Precast Concrete Products

E. International Conference of Building Officials (ICBO)

1.05 DEFINITIONS

A. Regular Precast: Acoustical barrier panels and such other members or components as indicated.

B. Architectural Precast: Stair components, windscreen and bench components, bollards precast concrete bases, and such other architectural precast members or components as indicated.

1.06 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit Shop Drawings showing the following:

1. Detailed drawings of panels, members, and components, showing dimensions and sections of each.

2. Quantities, dimensions, and locations of sleeves, anchors, brackets, inserts, reglets, reinforcing steel, lift devices, accessories, and methods of securing same in forms.

3. Casting, consolidating, and finishing procedures.

C. Product Data: Submit manufacturer's product data of manufactured products and accessories. Include manufacturer's detailed drawings and dimensions when applicable.

D. Samples: Samples require approval of the Engineer, as follows:

1. For precast concrete to be exposed in the finished work to public view, submit form facing material, 12 inches by 12 inches or larger in size as appropriate.

2. For precast concrete to receive sandblasted or other surface finish, submit sample of concrete with specified finish, 12 inches by 12 inches or larger in size as appropriate.

E. Quality Plan: In compliance with applicable requirements of Section 01 45 00, Quality Control, the Contractor shall provide a quality control plan to ensure uniformity of materials, conformance with accepted mix designs, and compliance with these Specifications.

F. Certificates:

1. Submit evidence of current plant certification under the PCI Plant Certification Program or approval by the International Conference of Building Officials (ICBO).

2. Submit manufacturers' certifications of compliance for materials as required by PCI MNL-117.

3. For welders, furnish welding certificates or affidavits attesting to the welders' qualifications to perform the indicated and specified welding.

1.07 QUALITY ASSURANCE

A. Qualifications of Fabricator:

1. Fabricator of precast concrete products shall be an active and approved participant in the PCI Plant Certification Program or an ICBO-approved precast fabricator.

2. Precast concrete work shall be produced in a plant or production facility by a fabricator who has been regularly and continuously engaged in the manufacture of precast concrete products.

3. Fabricator shall have sufficient production capacity to produce the required units without causing any delay in the work.

B. Qualifications of Welders: Welders shall be prequalified in accordance with AWS D1.1/D1.1M or AWS D1.4/D1.4M, as applicable to the work.

C. Tolerances: Fabricate and erect precast concrete members within the tolerances recommended in PCI MNL-117.

D. Mock-Ups: Construct sample panel or unit at the casting plant, of the actual item, or section of item not less than 10 square feet in surface area, of the features, finish, and color of concrete surfaces exposed to public view, for review and acceptance by the Engineer, prior to starting production.

E. Control Samples: All finishes and colors shall match the Engineer's control samples. Control samples require the Engineer's approval before they may be used as a standard.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Transport, handle, and store units in a manner that will prevent damage to the members.

B. If storage of precast units at the site is necessary, store units in a manner that will prevent cracking, distortion, staining, or other damage. Support members at their normal support points.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Reinforcing Steel: Comply with applicable requirements of Section 03 20 00, Concrete Reinforcing.

B. Portland Cement Concrete:

1. Comply with applicable requirements of Section 03 05 15, Portland Cement Concrete. Provide class of concrete as indicated.

2. When a dense, high-strength concrete is required, as for stair treads, a fly ash or pozzolanic admixture (ASTM C618), not to exceed 10 percent of the weight of the cement, may be introduced in the mix along with the required plasticizer (ASTM C1017/C1017M) or water-reducing admixtures (ASTM C494/C494M, Type F or Type G).

3. Provide white portland cement and crushed white aggregate where required to achieve colored concrete matching the approved control sample.

4. Coloring material for colored concrete shall be a standard commercial brand of chemically inert mineral oxide coloring material accurately measured by weight in a definite manner for each batch of concrete to produce a consistently even color. Material shall be readily dispersable in water. Color shall be as selected by the Engineer from samples prepared and submitted by the Contractor.

C. Anchors, Lift Devices, and Accessories: Provide concrete inserts, reglets, anchors, brackets, and fasteners as indicated or required for fabrication and installation work. All items shall be zinc-coated or galvanized in accordance with ASTM A153/A153M or ASTM A123/A123M, as applicable. Contractor shall select the lift devices, and shall be responsible for their performance and for any damage resulting from the use of faulty or inferior devices. Lift devices shall not be visible on exposed faces of precast members.

D. Stair Nosings: Refer to stair nosing specified in Section 05 50 00, Metal Fabrications.

E. Dielectric Insulation at Platform Edge:

1. Dielectric insulation membrane shall be as specified in Section 07 13 19, Modified Bituminous Sheet Waterproofing.

2. Dielectric insulation for dowels shall be terluran resin plastic ribbed or deformed sleeves conforming to the following requirements:

   a. Tensile strength at yield (ASTM D638): 45 MPa (6.5 ksi)

   b. Shear modulus (ASTM D638): 900 MPa (130.5 ksi)

   c. Impact strength, at 23 degrees C (ASTM D1622/D1622M): No break

   d. Volume resistivity (ASTM D257): 10^{15} Ω-cm minimum

3. Epoxy grout: Grout for securing plastic sleeves to concrete slab and to precast concrete platform edge units and to secure dowel within plastic sleeve shall be a non-shrink vinyl-ester resin designed to adhere to plastic, steel, and concrete.

F. Noise Abatement Seal:

1. Provide noise abatement seal at juncture of acoustical barrier panels and concrete girders, of size, profile, and configuration indicated. Seal shall be manufactured of dense neoprene meeting requirements of ASTM C542 for durometer A hardness of 75, plus or minus 5, when tested in accordance with ASTM D2240. Color: black.

2. Provide end plugs for each length of seal, one for each end. Plugs shall be manufactured of closed cell neoprene meeting requirements of ASTM C509, Type II.

2.02 FABRICATION

A. Requirements and Standards:

1. Manufacture precast concrete units in accordance with PCI MNL-122, PCI "Architectural Precast Concrete," and applicable requirements of ACI 318, Chapter 16.

2. Forms shall be accurately constructed to produce members to dimension, shape, configuration, and profile indicated. When not otherwise indicated, construct forms to produce smooth concrete.

3. Concrete reinforcement, lifting reinforcement, and concrete inserts and anchorage devices shall be placed and secured against movement as required. Place stair nosings and secure against movement as indicated.

4. Concrete shall be placed and consolidated to shape, configuration, and dimensions indicated.

5. Members shall be moist cured in accordance with curing requirements specified in PCI MNL-117. Minimum curing period for combined initial curing and secondary curing shall be seven Days or until the specified strength of concrete is attained.

B. Finishes:

1. Provide finishes for exposed concrete matching approved samples and mock-ups and the approved control samples.

2. When sandblasted finish is indicated, provide "sandblast finish" as specified in ACI 301. Degree of sandblasting shall be as required to provide surface finish matching the approved control sample.

3. For those items not exposed to public view, provide "smooth form finish" as specified in Section 03 35 00, Concrete Finishing.

C. Markings: Provide permanent markings in precast units to identify pick-up points and orientation in the structure, conforming with the markings indicated on Shop Drawings. Imprint the date of casting on each precast unit where it will not show in the finished structure.

2.03 QUALITY CONTROL

A. In accordance with Section 01 45 00, Quality Control, the Contractor-employed independent testing laboratory or agency shall perform such inspections and tests as required to verify compliance with these Specifications. All such inspections and tests shall be conducted at no additional cost to the District.

B. Concrete shall be tested for compressive strength as specified in Section 03 05 15, Portland Cement Concrete. A set of seven cylinders shall be prepared for every ten precast units, or fraction thereof, cast in any one day. Two cylinders shall be tested at three Days, two cylinders at seven Days, two cylinders at 28 Days, and one cylinder shall be retained for further testing as may be required. Cylinders shall be prepared and moist cured in accordance with ASTM C31/C31M, and tested in accordance with ASTM C39/C39M.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Examine all parts of the supporting structure and the conditions under which the precast concrete units are to be erected and installed. Verify the locations of anchors to pre-determine the accuracy of the installation of each member.

3.02 ERECTION/INSTALLATION

A. Transport and erect precast concrete units in accordance with PCI MNL-117 and as specified herein.

B. Erect precast concrete units and accurately install in place with mechanical hoisting equipment more than adequate for the loads.

C. Maintain precast concrete unit in upright position at all times. Handle unit only by indicated lifting devices or cushioned pads, and in a manner that will not overstress or damage the unit.

D. Erect precast concrete units in accordance with indicated erection tolerances. Comply with erection sequences indicated. Position units to avoid eccentric application of forces, and make complete and uniform contact with bearing surfaces.

E. Provide anchorage and attachment welding and bolting, as indicated, in accordance with PCI MNL-117, Division VI. Provide touch-up painting of field welds and abraded steel surfaces as specified in Section 09 91 00, Painting.

F. At completion, units shall be plumb, level, and square, true to line, with angles and edges parallel with related building lines.

G. Install noise abatement seals as indicated. Compress at least 15 percent to form a tight seal.

H. Provide sealant material and application, where indicated, in accordance with applicable requirements of Section 07 90 00, Joint Protection.

END OF SECTION 03 40 00

SECTION 03 53 00

CONCRETE TOPPING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Formwork.

B. Reinforcing Steel.

C. Bond Breaker Membrane.

D. Joint Fillers and Sealers.

E. Portland Cement Concrete.

F. Nonslip Aggregate Materials.

G. Concrete Hardener.

H. Concrete Curing Materials.

1.02 RELATED SECTION

A. Cast-in-place concrete is specified in Section 03 30 00, Cast-In-Place Concrete.

B. Portland cement concrete is specified in Section 03 05 15, Portland Cement Concrete.

C. Finishing and curing of concrete slabs are specified in Section 03 35 00, Concrete Finishing.

D. Formwork is specified in Section 03 11 00, Concrete Forming.

E. Reinforcing Steel is specified in 03 20 00, Concrete Reinforcing.

F. Joint filler and sealants are specified in 03 15 00, Concrete Accessories.

G. Sealant color specified in 07 90 00, Joint Protection.

1.03 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for concrete topping slabs will be either by the lump-sum method or by the unit-price method as determined by the listing of the bid item for concrete topping slabs indicated in the Bid Schedule of the Bid Form.

B. Lump-Sum: If the Bid Schedule indicates a lump-sum for concrete topping slabs, the lump-sum method of measurement and payment will be in accordance with Section 01 20 00, Price and Payment Procedures, Article 1.03.

C. Unit Prices: If the Bid Schedule indicates a unit price for concrete topping slabs, the unit-price method of measurement and payment will be as follows:

1. Measurement

2. Concrete topping slabs will be measured for payment by the cubic yard, and quantities will be computed, based on the neat lines or pay lines, section profiles, and dimensions shown on the Contract Drawings, without deduction for chamfers, reinforcing steel and embedded items, and openings and recesses having an area of less than two square feet.

   a. Expansion joints will not be measured separately for payment.

   b. Additional concrete used to replace overcut or for overbreak, or to repair or replace defective work, will not be measured separately for payment.

3. Payment: Concrete topping slabs will be paid for at the indicated Contract unit prices for the computed quantities as determined by the measurement method specified above.

1.04 REFERENCES

A. American Concrete Institute (ACI):

1.	ACI 117	Specification for Tolerances for Concrete Construction and Materials and Commentary
2.	ACI 301	Specifications for Structural Concrete
3.	ACI 302.1R	Recommended Practice for Concrete Floor and Slab Construction
4.	ACI 304	Measuring, Mixing, Transporting, and Placing Concrete

B. American Society for Testing and Materials (ASTM):

1.	ASTM C618	Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
2.	ASTM C1017/ C1017M	Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete
3.	ASTM D1751	Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
4.	ASTM D2178/ D2178M	Standard Specification for Asphalt Glass Felt Used in Roofing and Waterproofing
5.	ASTM D2047	Test Method for Static Coefficient of Friction of Polish-Coated Floor Surfaces as Measured by the James Machine

C. United States Access Board:

1. ADAAG Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings:

1. Submit drawings that indicate the locations of all joints in concrete slabs, including construction joints, expansion joints, isolation joints, weakened plane joints and contraction joints. Comply with the requirements specified in Section 03 11 00, Concrete Forming.

2. Submit drawings that indicate concrete placement method, sequence, and location.

C. Product Data: Submit manufacturers' product data for nonslip floor ingredients, concrete hardener material, control joint sealant, and expansion joint sealant.

D. Samples: Submit 1/2-pint sample container of aluminum oxide anti-slip materials for approval. Samples require approval of the Engineer before they may be incorporated in the Work.

E. Submit concrete mix design comply with the requirements specified in Section 03 05 15, Portland Cement Concrete.

1.06 QUALITY ASSURANCE

A. Specialist Applicator and Installer: Topping slabs shall be installed and finished by a skilled and experienced installer specializing in the installation and finishing of architectural concrete slabs. The Contractor shall submit evidence that the slab installer and finisher is approved by the manufacturer of the nonslip materials.

B. Floor Finish: "Nonslip finish" in combination with a "troweled finish" or fine "broom finish" conforming to applicable requirements of ACI 301.

C. Floor Tolerance: "Flat" tolerance conforming to ACI 117.

D. Cold Joints: Cold joints in concrete will not be permitted unless planned and treated properly as construction joints and submitted for approval as specified under submittals above.

E. Site Mock-Ups: Refer to Section 01 43 38, Field Samples and Mockups, for mock-up requirements. Provide site mock-up, at least 3 feet by 4 feet in size, of exposed slab finish for the Engineer's review and approval. Provide additional mock-ups, as required, until the desired finish is obtained. Site mock-up requires approval of the Engineer before work may proceed.

1. Different concrete finishes and colors shall be included and represented on the sample mock-up panel with a minimum 18 by 18 inch area for each different finish.

2. Include typical expansion joint detail and control joint in mock-up.

3. Approved sample panel shall not remain as part of the Work. Remove sample after final Acceptance of project.

F. Manufacturer's Instructions: Application of the nonslip floor ingredients and concrete hardener material and finishing of the concrete topping slabs shall be in accordance with the written or printed instructions and recommendations of the manufacturer of nonslip floor ingredients and concrete hardener materials.

G. Manufacturer's Field Services: The Contractor shall engage the manufacturer of the nonslip floor ingredients and concrete hardener materials to provide field services in accordance with the requirements of Section 01 43 00, Quality Assurance.

H. Surfaces shall maintain a minimum coefficient of friction as specified by the ADAAG Appendix to Part 1192 Advisory Guidelines Section 1.

PART 2 – PRODUCTS

2.01 TOOLS AND EQUIPMENT

A. The Contractor shall furnish all materials, tools, equipment, facilities, and services as required for performing the required topping slab placing and finishing work.

2.02 MATERIALS

A. Formwork: Refer to Section 03 11 00, Concrete Forming, for requirements.

B. Reinforcing Steel: Refer to Section 03 20 00, Concrete Reinforcing, for requirements.

C. Bond Breaker Membrane: ASTM D2178/D2178M asphalt glass felt, Type III - standard ply sheet.

D. Joint Fillers and Sealers: Refer to Section 03 15 00, Concrete Accessories, for requirements.

E. Portland Cement Concrete: Comply with Section 03 05 15, Portland Cement Concrete, and the following requirements:

1. Topping slab concrete shall have a minimum compressive strength at 28 Days of 4,000 psi. Maximum size of aggregate shall be one inch, except that 3/8 inch maximum size aggregate shall be used for locations where congestion and other conditions indicate the need for smaller aggregate. Minimum cement content per cubic yard of concrete shall be six and a half 94-pound sacks.

2. Mix design for topping-slab concrete shall include up to ten percent replacement of the cement content with fly ash (ASTM C618) along with a plasticizing admixture, conforming with ASTM C1017/C1017M, to provide a dense and plastic concrete mix which will trowel more easily with less surface bleeding of water.

F. Nonslip Aggregate Material: Crushed ceramically bonded or fused aluminum oxide as specified in ACI 301. Provide 25 pounds per 100 square feet as specified. All aggregate particles shall pass a No. 8 U.S. Standard Sieve, and shall be graded from No. 16 to No. 8 mesh.

G. Concrete Hardener and Dustproofer: Chemical clear liquid hardener which produces a dense, hard, and dustproof concrete surface, manufactured specifically for the intended purpose.

H. Concrete Curing Materials: Refer to Section 03 35 00, Concrete Finishing, for requirements.

1. Provide for damp curing only. Curing compound will not be permitted on floors to receive concrete hardener and dustproofer.

2.03 CONTROL AND EXPANSION JOINT SEALANT

A. Joint Filler and Sealants: Refer to Section 03 15 00, Concrete Accessories, for requirements. Provide a two-component elastomeric polyurethane sealant that is mixed and poured in place. When cured, it shall form a resilient joint seal with a high resistance to penetration and abrasion, and shall remain flexible through exposure to weather and aging. Sealant shall be self-leveling.

B. Sealant Color: Submit color chart in accordance with submittal requirements of Section 07 90 00, Joint Protection.

C. Expansion Joint Filler: One-half inch thick in accordance with ASTM D1751, pre-molded non-extruding asphalt impregnated felt.

2.04 CONTROL JOINT FORMING

A. Comply with requirements of Section 03 30 00, Cast-In-Place Concrete.

B. Control joints shall be straight and true, of equal depth and width the full length of the joint. Arrange and locate joints as shown on the Construction Drawings.

C. Form control joints only by saw cutting surface of concrete.

PART 3 – EXECUTION

3.01 INSTALLATION REQUIREMENTS:

A. The requirements of Section 03 30 00, Cast-In-Place Concrete, Section 03 05 15, Portland Cement Concrete, and Section 03 35 00, Concrete Finishing, shall apply to the work of this Section as applicable.

3.02 EXAMINATION

A. Inspect forms, structural slab surfaces, waterproof membranes and protection board where they occur, reinforcement, and embedded items, and obtain the Engineer's approval thereof before placing concrete. Complete and sign a pour card on the form supplied by the Engineer. The Engineer will countersign the card upon the completion of hold points and prior to commencing the pour.

3.03 PREPARATION

A. At least 48 hours prior to actual placement, notify the Engineer and nonslip material manufacturer's representative of the intention to deliver and place concrete.

B. Before placing concrete, broom clean structural slab surfaces and install bond breaker membrane where indicated. Lap edges and ends of asphalt glass felt 6 inches. Small dabs of bituminous cement may be used to hold felt sheets in place during subsequent placing operations.

3.04 PLACING AND FINISHING

A. Placement and Finishing Standards: Concrete topping slabs shall be placed, consolidated, and finished in accordance with applicable requirements of ACI 301.

B. Placement:

1. Topping slabs shall be placed and finished monolithically. Strike off and screed slabs to true, plane surfaces at required elevations, and thoroughly compact concrete with vibrators, floats, and tampers to force coarse aggregate below the surface. Finish slab within four hours of concrete placement.

2. Whether indicated or not, in areas where drains occur, slope finished slab to drains. Slope shall be a minimum of 1/8 inch per foot unless otherwise indicated.

C. Finishes:

1. Topping slabs shall receive a "troweled finish" or fine "broom finish" in combination with a "nonslip finish," as selected by the Engineer from Contractor-prepared mock-ups, with "flat" tolerance, as specified in ACI 117.

2. Application of the nonslip material and finishing of the topping slabs shall conform with the nonslip material manufacturer's application instructions and recommendations.

3.05 CURING

A. Curing of concrete topping slabs shall conform with applicable requirements of ACI 301, except that the duration of the curing period shall be ten Days minimum.

B. Provide damp curing only as specified in Section 03 35 00, Concrete Finishing. Curing compounds will not be permitted.

3.06 APPLICATION OF CONCRETE HARDENER

A. Allow slab surfaces to cure and dry a minimum period of 28 Days before applying hardener/dustproofer material. Slab surfaces shall be clean and dry at the time hardener/dustproofer material is applied.

B. Apply clear liquid hardener/dustproofer compound to slab surfaces, after the damp-curing and drying period, in accordance with the manufacturer's application instructions. Rate of application and number of coats shall conform with the manufacturer's instructions and recommendations.

3.07 PROTECTION

A. Protect exposed concrete slab surfaces as required to prevent damage from impact or stains.

B. Protect fresh concrete from drying winds, rain, damage, or soiling.

C. Refer to Section 03 30 00, Cast-In-Place Concrete, Article 3.09, for additional requirements.

END OF SECTION 03 53 00

SECTION 03 61 11

NON-SHRINK GROUT

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Cementitious Grout.

B. Epoxy Grout.

C. Epoxy Adhesive.

1.02 RELATED SECTIONS

A. Grout for prestressed concrete is specified in Section 03 05 18, Prestressed Concrete.

B. Masonry grout for filling cells of unit masonry is specified in Section 04 22 00, Concrete Unit Masonry.

C. Grout for filling and finishing joints of ceramic tile and cut stone is specified in applicable sections under Division 9 – Finishes.

D. Grout for concrete repair and finishing materials is specified in Section 03 35 00, Concrete Finishing.

E. Grout for metal railings is specified in Section 05 52 00, Metal Railings.

1.03 MEASUREMENT AND PAYMENT

A. Measurement: Grout work will not be measured separately for payment.

B. Payment: Grout work will be paid for as part of the indicated Contract price for the work or structure in which the grout is used.

1.04 DEFINITION:

A. For the purpose of these Specifications, “non-shrink grout” shall be defined as a high-strength mortar or grout which does not shrink in the plastic state, is dimensionally stable in the hardened state, and bonds permanently to clean metal surfaces and concrete substrate.

1.05 REFERENCES

A. American Concrete Institute (ACI):

1. ACI 503.2 Standard Specification for Bonding Plastic Concrete to Hardened Concrete with a Multi-Component Epoxy Adhesive

B. American Society for Testing and Materials (ASTM):

1.	ASTM C109/C109M	Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or 50-mm Cube Specimens)
2.	ASTM C157/C157M	Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete
3.	ASTM C579	Standard Test Methods for Compressive Strength of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings and Polymer Concretes
4.	ASTM C827/C827M	Standard Test Method for Change in Height at Early Ages of Cylindrical Specimens from Cementitious Mixtures
5.	ASTM C881/C881M	Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
6.	ASTM C939	Standard Test Method for flow of Grout for Replaced-Aggregate Concrete (Flow Cone Method)
7.	ASTM C1090/ C1090M	Standard Test Method for Measuring Changes in Height of Cylindrical Specimens of Hydraulic-Cement Grout
8.	ASTM C1107/ C1107M	Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)

C. U. S. Army Corps of Engineers, Concrete Research Division (CRD):

1.	CRD-C620	Standard Method of Sampling Fresh Grout
2.	CRD C621	Corps of Engineers Specification for Non-shrink Grout

1.06 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Product Data: Submit manufacturer’s product data and installation instructions.

C. Certification: Submit certificates of compliance or laboratory test reports which indicate the following:

1. Materials used in the grout are free from metallic components and corrosion-producing elements.

2. Materials meet specified shrinkage and compressive strength requirements.

1.07 ENVIRONMENTAL REQUIREMENTS

A. Handle grout the same as concrete with regard to temperature and curing, as specified in Section 03 30 00, Cast-In-Place Concrete, Section 03 05 18, Prestressed Concrete, and Section 03 35 00, Concrete Finishing.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Cementitious Grout: Provide non-shrink, non-metallic, non-corrosive cement-based grout conforming to the following requirements:

1. Applicable Standards: ASTM C1107/C1107M and CRD-C621.

2. Grout shall be manufactured specifically for use in supporting heavy loads (loads in excess of 300 pounds per square foot concentrated load or 100 pounds per square foot uniform load). Grout: ASTM C1107/C1107M, Grade A, B, or C, as appropriate for the condition or circumstance.

3. Shrinkage at 28 Days: No shrinkage before hardening (0.00 shrinkage when tested in accordance with ASTM C827/C827M and ASTM C1090/C1090M); no shrinkage after hardening (0.00 shrinkage when tested in accordance with CRD-C621).

4. Compressive strength, minimum as specified in ASTM C1107/C1107M, Table 1:

   a. At one Day: 1000 psi

   b. At three Days: 2500 psi

   c. At seven Days: 3500 psi

   d. At 28 Days: 5000 psi

5. Initial setting time, after addition of water: approximately one hour at 70 degrees Fahrenheit.

6. Provide nonsag trowelability or flowability as necessary for the particular application.

B. Water: Clean and potable, free of impurities detrimental to grout.

C. Epoxy Grout: Provide non-shrink, non-metallic, non-corrosive epoxy grout conforming to the following requirements:

1. Grout shall be manufactured specifically for use in supporting heavy loads.

2. Shrinkage at 28 Days: None (0.00 shrinkage when tested in accordance with ASTM C827/C827M modified procedure) with a minimum effective bearing area (EBA) of 95 percent coverage of the tested base plate.

3. Compressive strength, minimum: 10,000 psi at seven Days, when tested in accordance with ASTM C579.

4. Initial setting time: Approximately one hour at 70 degrees Fahrenheit.

5. Provide flowable consistency as necessary for the particular application.

6. Epoxy grouts which are volatile and which give off noxious fumes are not acceptable.

D. Epoxy Adhesive: ASTM C881/C881M, Type V, epoxy-based bonding agent.

2.02 MIXING

A. Mix grout ingredients for both cementitious grout and epoxy grout in accordance with the respective manufacturer's mixing instructions and recommendations. Mix grout materials in proper mechanical mixers.

B. Mix grout as close to work area as possible.

2.03 SOURCE QUALITY CONTROL

A. Inspections and Tests: Perform visual inspections and shrinkage tests using an appropriate independent testing laboratory, and strength tests as necessary to verify performance requirements of grout. Sampling and testing of grout shall conform with applicable ASTM or CRD-C620 requirements. The independent testing laboratory shall perform sampling, testing, and inspection in accordance with the provisions herein. The Contractor shall cooperate with and notify District at least 48 hours in advance of sampling, tests, and inspections being performed by the independent testing laboratory. District may elect to observe these procedures.

B. Visual Inspections: Perform visual inspection of the grout mixing and placement to determine and verify that grout consistency, slump, and stiffness are appropriate and proper for the location and type of installation.

C. Shrinkage Tests:

1. Cementitious Grout: Grout shall meet the following performance requirements:

   a. Expansion: 0.4 percent maximum at three, 14, and 28 Days. Grout shall exhibit no displacement when tested in accordance with ASTM C157/C157M.

   b. Shrinkage: None (0.00 shrinkage at 28 Days when tested in accordance with ASTM C827/C827M and ASTM C1090/1090M). There shall be no vertical volume shrinkage of grout in the plastic or hardened stage at any time.

2. Epoxy Grout: Grout shall meet the following performance requirements:

   a. Expansion: Grout shall exhibit no displacement when tested in accordance with ASTM C827/C827M and ASTM C157/C157M, modified procedures.

b. Shrinkage: None (0.00 shrinkage when tested in accordance with ASTM C827/C827M, modified procedure; specific gravity of indicator ball will be changed to approximately 1.0).

c. Effective Bearing Area: 95 percent minimum coverage of the tested base plate.

D. Strength Tests: Compressive strength of grout shall meet the following requirements:

1. Cementitious Grout: 5,000 psi minimum at 28 Days when tested in accordance with ASTM C109/C109M.

2. Epoxy Grout: 10,000 psi minimum at seven Days when tested in accordance with ASTM C579.

PART 3 – EXECUTION

3.01 SURFACE PREPARATION

A. Concrete surfaces to receive grout shall be prepared by chipping, sandblasting, water blasting, or other accepted methods to remove defective concrete, laitance, dirt, oil, grease, and other foreign matter to achieve sound, clean concrete surfaces. Lightly roughen concrete for bond, but not enough to interfere with proper placement of grout.

B. Cover concrete areas with protective waterproof covering until ready to place grout.

C. Remove foreign matter from steel surfaces to be in contact with grout. Clean contact steel surfaces as necessary by wire brushing and wiping dust clean.

D. Align and level components to be grouted, and maintain in final position until grout placement is complete and accepted.

E. Install forms for grout around the column base plates and other spaces to be grouted. The tops of such forms shall be one inch above the surfaces to be grouted.

F. Remove protective waterproof covering and clean contaminated surfaces immediately before grouting.

G. Provide air-relief holes in large baseplates and in baseplates where underneath obstructions may cause air entrapment.

H. Saturate concrete surfaces with clean water, and remove excess water immediately before grouting.

I. Where necessary or appropriate for better bond, epoxy adhesive may be applied to clean, dry substrate surfaces in accordance with applicable requirements of ACI 503.2.

3.02 PLACING GROUT

A. Place grout in accordance with the respective manufacturer's installation instructions and recommendations. Pour grout from one side only until grout rises at least one inch above the plate on opposite side of said plate. Strapping and plunging or other recommended method may be used to force grout to flow under the entire area.

B. Neatly trowel edges of grout base, tapered at an angle of 60 degrees when measured from the horizontal, or as indicated. Provide dry-pack cementitious grout where additional grout is required for shoulders.

C. Do not remove leveling shims for at least 48 hours after grout has been placed.

D. After shims have been removed, if used, fill voids with grout, packing the material with a suitable tool.

E. Do not use grout which has begun to set or if more than one hour has elapsed after initial mixing.

3.03 CURING

A. Cementitious grout shall be cured the same as specified for concrete in Section 03 35 00, Concrete Finishing.

B. Epoxy grout shall be cured as recommended by the grout manufacturer.

END OF SECTION 03 61 11

SECTION 04 01 20

UNIT MASONRY RESTORATION

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Cutting and Chipping.

B. Repairing of Cracks.

C. Restoration Work.

D. Removal of Paint.

E. Cleaning.

1.02 RELATED SECTIONS

A. Coordinate the Work of this Section with the Work of other Sections specifying remedial work, corrective measures, and restoration work, including Section 01 71 23, Field Engineering, Section 01 74 14, Cleaning, Section 02 41 19, Selective Structure Demolition, and Section 09 91 00, Painting.

1.03 MEASUREMENT AND PAYMENT

A. Measurement: Repair and restoration of existing masonry will be measured for payment by the lump-sum method, acceptably performed and completed.

B. Payment: Repair and restoration of existing masonry will be paid for at the indicated Contract lump-sum price as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM C881/ C881M — Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
2. ASTM C928/ C928M — Standard Specification for Packaged, Dry Rapid-Hardening Cementitious Materials for Concrete Repairs
3. ASTM C1107/ C1107M — Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Non-shrink)

1.05 DEFINITIONS

A. The station or building involved in this work will be in continuous operation during the construction period. This will require that the Contractor plan the Work carefully to

work around unavoidable obstacles in the prosecution of the Work. It will require further that the Contractor complete some new construction facilities required in the renovation work before proceeding with the masonry restoration work.

B. Provide such additional temporary facilities as may be required to facilitate continuous, unobstructed station or building operations during transitional construction work.

1.06 REGULATORY REQUIREMENTS

A. In addition to the foregoing referenced standards, the regulatory requirements that govern the work of this Section include the following code requirements:

California Code of Regulations (CCR), Title 24, Part 10, California Existing Building Code and California Code of Regulations (CCR), Title 24, Part 2, California Building Code, Chapter 34A, “Existing Structures.”

1.07 QUALITY ASSURANCE

A. Repair and restoration of existing masonry surfaces shall be performed by a skilled and experienced subcontractor specializing in the restoration of masonry with at least five years’ experience in the type of work involved.

B. Repair and restoration of existing stone and unit masonry work shall achieve security, strength, and weather protection, as applicable and required, and shall preserve the integrity and continuity of fire-rated assemblies.

C. Repair and restoration of existing masonry work shall successfully duplicate undisturbed adjacent finishes, colors, textures, and profiles. Where there is a dispute as to whether or not duplication is successful or has been achieved to a reasonable degree, the Engineer’s judgment shall be final.

PART 2 – PRODUCTS

2.01 MATERIALS, EQUIPMENT, AND FACILITIES

A. Requirements: Provide all materials, equipment, tools, appurtenances, facilities, and services as required for performing and completing all repair and restoration of existing stone and unit masonry as indicated.

B. Equipment, Tools, and Materials: Provide appropriate and proper equipment, tools, and materials for the chipping and air-pressure cleaning of cracks in masonry, for pressure injection grouting of cracks in mortar joints, for sandblasting or water-blasting of masonry surfaces, and for hose cleaning of masonry.

C. Stone and Unit Masonry Materials: Where cut stone or concrete masonry units are damaged and require replacement, provide new stone or masonry units that match exactly the species, color, and texture of adjacent masonry surfaces. Replacement

cut stone and concrete masonry units require approval of the Engineer before they may be used in the work.

D. Mortar Bonding Agent: Adhesive for the bonding of new mortar and grout to existing masonry and mortar shall be an epoxy adhesive meeting requirement of ASTM C881/C881M, of type required for the conditions.

E. Mortar Repair Materials:

1. Mortar: Mortar for joints and tuckpointing shall be an epoxy mortar, polymer-fortified mortar, or similar high-strength bonding mortar conforming with ASTM C928/C928M. Minimum compressive strength at 28 Days shall be 2,500 psi.

2. Sand: Sand shall be a clean, washed, kiln-dried, fine sand, all passing a U.S. Standard No. 16 sieve.

F. Grout: Grout for pressure-injection grouting shall be a high-strength, nonshrink, cementitious, adhesive grout conforming with ASTM C1107/C928M, Grade C, or a high-strength, non-shrink, manufactured epoxy adhesive grout. Minimum compressive strength at 28 Days shall be 4,000 psi.

G. Cleaning Agent: Mild solution of hydrochloric acid or muriatic acid, for washing of stubborn stains on masonry.

PART 3 – EXECUTION

3.01 REQUIREMENTS

A. Perform cutting, chipping, patching/restoring work, and cleaning in a manner to prevent damage to other work, and as required to return exterior building surfaces to essentially their original condition and configuration.

B. Major cracks shall be repaired and filled by pressure-injection grouting. All other cracks shall be repaired in the manner most appropriate and as required for weatherproofing or waterproofing the building or structure.

C. Do not cut or alter structural members when not indicated without prior approval of the Engineer.

D. Finish or refinish as required to match adjacent finishes.

3.02 CUTTING AND CHIPPING

A. Cutting and chipping work shall be neatly and accurately performed with proper tools and equipment. Cuts shall be of minimum size required for the work. Check the locations carefully of existing steel reinforcement before cutting or chipping.

B. Existing work to remain shall be properly protected to prevent damage from cutting and chipping operations.

3.03 REPAIRING OF CRACKS

A. Cracks shall be repaired and filled with grout by the pressure-injection process. Masonry joint cracks shall be mapped, and the injection shall be on center-to-center spacings as necessary to achieve proper structural bonding. Replace all cut stone and masonry units that have cracks across the face.

B. Adhesive material shall be mixed with grout in proportion necessary to provide structural bonding of concrete. Grout material shall be inserted into cracks by pressure-injection grouting in accordance with the manufacturer's installation instructions and recommendations.

C. Minor cracks too small for injection grouting shall be repaired as specified in Article 3.04 for restoration work.

D. Small holes, cracks, and other imperfections to be painted shall be suitably primed and patched with a compound recommended by the manufacturer of the paint to be applied to these surfaces as specified in Section 09 91 00, Painting.

3.04 RESTORATION WORK

A. Preparation of Existing Surfaces: Where masonry is cracked or spalled, cut or chip out to solid surface. Use power wire brush and high pressure air to clean masonry of dirt, dust, and loose particles. Clean exposed reinforcing bars with power wire brushing to remove all visible corrosion.

B. Repairing of Masonry:

1. Repairing and patching of existing masonry surfaces and joints shall be expertly performed with specified adhesive, mortar, and grout materials. At completion, patched surfaces shall match adjacent existing surfaces as closely as possible.

2. Mortar bonding agent, mortar, and grout shall be applied or installed where indicated, or where otherwise required, in accordance with the manufacturer's instructions and recommendations.

3. Where necessary to build out cut, spalled, or chipped masonry surfaces, mix mortar bonding agent, mortar, and sand into a special mortar, and apply in layers as required to fill out or build up surfaces. Float, trowel, or texture surfaces to match adjacent existing surfaces.

4. Where indicated or required to replace existing, damaged cut stone or concrete masonry units, expertly cut out damaged units with masonry saw or cutting wheel. Clean out all loose particles and dust with air-pressure cleaning. Then install new units to match adjacent existing masonry surfaces as closely as possible, including joint treatment.

C. Tuckpointing:

1. Joints of cut stone and concrete unit masonry shall be routed out and tuckpointed as herein specified. Only such tuckpointing shall be performed as required to put all joints of the building in good repair.

2. Faulty joints to be tuckpointed shall be routed out the full width of the existing joint with a machine masonry cutting wheel to a minimum depth of 3/8 inch into the existing mortar. Newly routed joints shall be washed clean before tuckpointing.

3. Tuckpointing mortar shall be the repair mortar specified in Article 2.01.E herein.

3.05 REMOVAL OF PAINT

A. Where removal of existing paint film is required for restoration of masonry surfaces, existing painted masonry surfaces shall be sandblasted by the “wet” sandblast method to remove all such paint film. Surfaces not to be sandblasted shall be properly masked and otherwise protected to preclude any damage to these surfaces.

B. Wet sandblasted surfaces shall be thoroughly dry or dried before painting work is started as specified in Section 09 91 00, Painting.

3.06 CLEANING

A. Where existing masonry surfaces are indicated to be cleaned or washed to remove dirt, dust, and stains, such surfaces shall be washed clean to an even and uniform effect, free of stains and blemishes. Include adjacent cornices, ledges, and masonry ornaments. Method of cleaning (e.g. high-pressure water, steam cleaning, or diluted acid cleaning) are subject to approval by the Engineer.

B. All adjacent glass areas shall be cleaned after washing of masonry surfaces.

C. Replace any glass damaged by the cleaning operations.

END OF SECTION 04 01 20

SECTION 04 22 00

CONCRETE UNIT MASONRY

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Concrete Masonry Units.

B. Epoxy Bonding Adhesive.

C. Control Joint Materials.

D. Joint Reinforcement.

E. Reinforcing Steel.

F. Precast Beams, Lintels and Copings.

G. Mortar.

H. Grout.

I. Surface Sealer.

1.02 RELATED SECTIONS

A. Reinforcing steel for concrete and connecting dowels for grouted unit masonry are specified in Section 03 20 00, Concrete Reinforcing.

B. Precast concrete beams, lintels, and copings are specified in Section 03 40 00, Precast Concrete.

1.03 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for concrete unit masonry will be either by the lump-sum method or by the unit-price method as determined by the listing of the bid item for concrete unit masonry indicated in the Bid Schedule of the Bid Form.

B. Lump Sum: If the Bid Schedule indicates a lump sum for concrete unit masonry, the lump-sum method of measurement and payment will be in accordance with Section 01 20 00, Price and Payment Procedures, Article 1.03.

C. Unit Price: If the Bid Schedule indicates a unit price for concrete unit masonry, the unit-price method of measurement and payment will be as follows:

1. Measurement:

   a. Concrete unit masonry will be measured by the square foot or square yard for each type of masonry unit and thickness of wall. No deductions will be made for openings less than 64 inches square.

   b. Vertical and horizontal steel reinforcement, control joints, mortar, grout, anchors, ties, masonry cleaning, sealer, and miscellaneous accessories will not be measured separately for payment; such items will be considered incidental to, and included with, the concrete unit masonry work.

2. Payment: Concrete unit masonry will be paid for at the indicated Contract unit prices for the computed quantities as determined by the measurement method specified in Article 1.03.C.1.

1.04 REFERENCES

A. The Masonry Society (TMS):

1. TMS 402/602 Building Code Requirements and Specification for Masonry Structures

B. American Society for Testing and Materials (ASTM):

1. ASTM C33/ C33M Standard Specification for Concrete Aggregates
2. ASTM C90 Standard Specification for Load-Bearing Concrete Masonry Units
3. ASTM C91/ C91M Standard Specification for Masonry Cement
4. ASTM C94/ C94M Standard Specification for Ready-Mixed Concrete
5. ASTM C109/ C109M Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or 50-mm Cube Specimens)
6. ASTM C140/ C140M Standard Methods of Sampling and Testing Concrete Masonry Units and Related Units
7. ASTM C143/ C143M Standard Test Method for Slump of Hydraulic Cement Concrete
8. ASTM C144 Standard Specification for Aggregate for Masonry Mortar
9. ASTM C150/ C150M Standard Specification for Portland Cement

10. ASTM C207	Standard Specification for Hydrated Lime for Masonry Purposes
11. ASTM C270	Standard Specification for Mortar for Unit Masonry
12. ASTM C404	Standard Specification for Aggregates for Masonry Grout
13. ASTM C426	Standard Test Method for Linear Drying Shrinkage of Concrete Masonry Units
14. ASTM C476	Standard Specification for Grout for Masonry
15. ASTM C881/ C881M	Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
16. ASTM C979/ C979M	Standard Specification for Pigments for Integrally Colored Concrete
17. ASTM C1006	Standard Test Method for Splitting Tensile Strength of Masonry Units
18. ASTM C1019	Standard Test Method for Sampling and Testing Grout

1.05 REGULATORY REQUIREMENTS

A. In addition to the foregoing referenced standards, the regulatory requirements that govern the work of this Section include the following governing code:

California Code of Regulations (CCR), Title 24, Part 2, California Building Code, Chapter 21, “Masonry,” and Chapter 21A, “Masonry.”

1.06 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: When not indicated in sufficient detail or definition, submit detailed drawings of unit masonry, showing type of mortar joints, bond pattern, reinforcing steel, connecting dowels, joint reinforcement, grouted cells, and control joints.

C. Product Data: Submit manufacturer’s product data for block, including available color range, epoxy adhesive, joint reinforcement, and control-joint materials, along with installation instructions where applicable.

D. Samples: Submit full-size sample of block and samples of colored mortar for approval. Block and colored joint mortar require approval of the Engineer before they may be used in the concrete masonry work.

E. Certificates: Submit certification stating that concrete masonry units meet specification requirements and that masonry units conform with the special strength requirements of these Specifications. Each certificate shall be signed by the masonry unit manufacturer and shall contain the name of the manufacturer, the project location, and the quantity and dates of shipment or delivery to which the certificate applies.

1.07 QUALITY ASSURANCE

A. Concrete unit masonry work shall conform with applicable requirements of the California Building Code, Chapters 21 and 21A, and TMS 402/602, except as modified in these Specifications.

B. Construction tolerances for concrete unit masonry shall conform with TMS 402/602.

C. Refer to Section 01 45 00, Quality Control, for additional requirements and procedures.

1.08 DELIVERY, HANDLING, AND STORAGE

A. Delivery masonry materials in undamaged condition. Store and handle materials to prevent their deterioration or damage due to moisture, temperature changes, contaminants, corrosion, or other causes.

B. Limit moisture absorption of concrete masonry units during delivery and until time of installation. Conform to handling and storage requirements in accordance with ASTM C90.

C. Store cementitious materials off the ground, under cover, and in a dry location.

D. Store and protect aggregates where grading and other required characteristics can be maintained.

E. Store and protect masonry accessories, including metal items, to prevent deterioration by corrosion and accumulation of dirt.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Concrete Masonry Units (Concrete Block):

1. Concrete masonry units shall be of modular face dimensions and thicknesses indicated. Furnish necessary shapes and sizes, bond-beam units, and corner units as required to satisfy conditions indicated. Include half-size units where indicated or required.

2. Concrete masonry units shall be hollow load-bearing units conforming to ASTM C90, and shall be No. 1 Normal Weight, No. 2 Medium Weight, or No. 3 Light Weight, as applicable, Type I - Moisture Controlled Units. Units shall have a maximum linear shrinkage of 0.06 percent when tested in accordance with ASTM C426, and shall meet water absorption requirements of ASTM C90.

3. Concrete masonry units shall be normal cement-colored units with standard face surfaces. Cinders or ingredients that might stain paint finishes will not be permitted in the manufacture of concrete masonry units.

B. Split-Face Concrete Masonry Units:

1. Split-face concrete masonry units shall conform with ASTM C90, as specified above for concrete masonry units, of modular face dimensions and thicknesses indicated. Face of units shall have special surface texture split-face, scored to dimensional module indicated. Minimum strength requirements shall conform with foregoing specified concrete masonry units.

2. Block shall have integral color as selected by the Engineer from manufacturer's standards.

C. Cement: ASTM C150/C150M, Type I or Type II Portland cement, low alkali. Provide white cement when required to achieve the mortar color selected by the Engineer. ASTM C91/91M, Type S, masonry cement may be used together with ASTM C150/150M portland cement as herein specified under "Mortar."

D. Lime: ASTM C207, hydrated, Type S.

E. Mortar Sand: ASTM C144, natural sand, clean and graded.

F. Mortar Coloring Pigment: ASTM C979/C979M, manufactured, inert mineral oxides in color or colors as selected and approved by the Engineer.

G. Grout Aggregate: ASTM C33/C33M or ASTM C404, clean and graded concrete aggregates, proportioned by volume as follows: three parts fine and graded concrete aggregate to two parts of graded 3/8-inch maximum size coarse aggregate.

H. Water: Fresh, clean, potable, free from deleterious amounts of acids, salts, alkali, mineral, and organic substances that would adversely affect the cement mortar, grout, and reinforcing.

I. Epoxy Bonding Adhesive: Adhesive for bonding of mortar bed to concrete slabs shall be an epoxy-based bonding agent conforming to ASTM C881/C881M, Type V, tinted to show by visual inspection where it has been applied.

J. Control Joint Materials: Conform with requirements of TMS 402/602.

K. Joint Reinforcement: No. 9 gage ladder or truss type steel wire conforming to TMS 402/602.

L. Reinforcing Steel: Provide reinforcing steel for grouted block masonry under this Section in accordance with the requirements of Section 03 20 00, Concrete Reinforcing, and TMS 402/602.

M. Precast Beams, Lintels, and Copings: Precast concrete of configuration indicated, conforming to requirements of Section 03 40 00, Precast Concrete, and TMS 402/602. Provide exposed surfaces with light sand-blasted finish matching finish of masonry units as closely as possible.

N. Single Source Responsibility:

1. Masonry Units: Obtain masonry units of uniform texture and color, or a uniform blend within the ranges accepted for these characteristics, from one manufacturer for each different product required for each exposed continuous surface or visually related surfaces.

2. Mortar Materials: Obtain mortar ingredients of uniform quality, including color for exposed masonry, from one manufacturer for each cementitious component and from one source and producer for each aggregate.

2.02 MORTAR

A. Mortar Type and Mixing Requirements:

1. Mortar for grouted unit masonry shall be Type S mortar in accordance with the California Building Code, Chapter 21 and 21A, TMS 402/602, and ASTM C270, with a minimum compressive strength at 28 Days of 1,500 psi. A minimum of two 94-pound sacks of portland cement (ASTM C150/C150M) shall be provided per cubic yard of mortar when using ASTM C91/C91M masonry cement.

2. The use of an admixture for the purpose of reducing water content in mortar will be permitted, provided the strength of the mortar is not reduced.

3. Mortar shall be job mixed and, in lieu of specific requirements specified herein, shall conform with ASTM C270, including measurement, mixing, proportioning, and water retention.

4. Accurately measure mortar ingredients and mix a minimum of three minutes after water has been added, in a mechanical batch mixer, using sufficient water to produce a workable and plastic consistency. Hand mixing will be permitted for small quantities only.

5. Use mortar within 2-1/2 hours after mixing when air temperature is 80 degrees or higher, and within 3-1/2 hours when air temperature is below 80 degrees. Discard any mortar that has been mixed longer or that has begun to set. If necessary, mortar may be retempered within this time limit, by replacing only water lost due to evaporation and by thorough remixing.

B. Colored Joint Mortar: Provide colored mortar for exposed masonry joints where indicated. Color shall be as approved by the Engineer from samples prepared and submitted by the Contractor. Pigment amount for selected color and mixing of colored mortar shall conform with the pigment manufacturer's instructions.

2.03 GROUT

A. Grout shall be Coarse Grout, as defined in ASTM C476, with a minimum compressive strength at 28 Days of 2,000 psi, and shall be proportioned by volume in accordance with TMS 402/602.

B. Grout mix shall be designed in accordance with ASTM C94/C94M for manufacturer designed mixes, and for handling by an approved grout pump. Slump shall be 8-10 inches.

C. The use of an admixture for the purpose of reducing water content in grout and adding flowability will be permitted, provided the strength of the grout is not reduced. Admixture shall be added to the mix as recommended by the manufacturer for the purpose intended.

2.04 SURFACE SEALER

A. Provide a water-based, VOC-compliant, clear, penetrating water-repellent sealer, designed to provide long-term protection against water absorption, for exterior concrete unit masonry surfaces. Submit sealer performance data and VOC compliance verification for approval.

PART 3 – EXECUTION

3.01 LAYING CONCRETE MASONRY UNITS

A. Installation Standards: Comply with applicable requirements of TMS 402/602.

B. Requirements: Construct concrete unit masonry to dimensions indicated. Concrete masonry units shall be dry when laid. Avoid using less than half-size units in exposed locations. Do not expose cells on any surface. Where concealed, spaces not large enough for full or half-size units may be filled with concrete building brick or mortar.

1. Basic layouts, positions, and elevations shall be as shown on the Construction Drawings. Unit layouts within each panel or wall area shall be made to achieve symmetrical, uniform appearance and to avoid cut units where possible.

2. Perform no work during rain or when outside temperature is 40 degrees Fahrenheit or lower, or when it appears probable that temperatures below 40 degrees Fahrenheit will be encountered before the mortar or grout has set.

3. Masonry walls shall be adequately braced against lateral loads during construction.

4. Do not apply loads for at least three Days after construction of masonry walls.

C. Work Quality:

1. Masonry work shall be performed by skilled and experienced masons. Erect walls plumb and true to line, with courses level and joints uniform in width, using specified mortar. Vertical joints shall line up plumb in exposed walls.

2. Concrete masonry units shall be sound and free of cracks and surface defects. Handle units carefully to avoid chipping and breaking. Do not substitute cut units where special shapes are available.

3. Where steel beams or joists frame into masonry, fill spaces with mortar and finish off flush with masonry surface, neatly pointed around steel. Where pipes and ducts penetrate masonry, point neatly and accurately around pipes and ducts.

D. Cutting of Units: Cutting of units shall be kept to a minimum. Perform cutting accurately to accommodate items passing through or embedded in masonry, to meet surfaces that masonry abuts, and to fit various conditions. Cutting of masonry units shall be performed with a power-driven masonry saw. Rub cuts smooth and even with carborundum or emery stone. Do not use chipped or cracked masonry units.

E. Bedding and Jointing:

1. Use full mortar bed and coverage on horizontal and vertical face shells of hollow units. Webs also shall be bedded in mortar. Shove vertical joints tight.

2. Top surfaces of concrete foundations or other bed joints shall be clean concrete with aggregate exposed before start of laying. Tops of foundations shall be roughened and cleaned to remove laitance for exposing aggregates in the concrete. Where block is to be laid on slabs, bed joints shall be roughened and cleaned, and an epoxy bonding adhesive shall be applied before laying first course of block.

F. Joint Reinforcement: Provide ladder or truss type joint reinforcement, spaced a maximum of 16 inches on center vertically. Place in accordance with TMS 402/602, fully embedded in mortar.

G. Bond Pattern: Lay masonry units in stretcher bond or running bond, unless otherwise indicated.

H. Alignment of Vertical Cells: Masonry shall be built to preserve the unobstructed vertical continuity of the cells. The vertical alignment shall be sufficient to maintain a clear, unobstructed vertical flue, measuring not less than 3 inches in all directions for grouted masonry.

I. Cleanouts: Cleanout openings shall be provided at the bottoms of cells to be filled with grout. Mortar droppings shall be removed from cells, and cleanouts shall be sealed after inspection and before grout placement.

J. Pipe Chases: Chases and recesses for conduits, pipes, and ducts shall be formed as masonry work is constructed. Do not enclose conduit runs until complete and approved, or piping until it has been tested and approved. Make such chases and recesses plumb, with inside joints struck flush, and the interiors kept free of obstructions and cleaned-out upon completion.

K. Anchorage and Embedded Items:

1. Set accurately in place and bond into masonry, as the masonry work progresses, bolts, straps, hangers, sleeves, anchors, inserts, frames for doors and windows, and any other anchorage items or attachments as indicated. Provide suitable recesses for cabinets, junction boxes, panels, and other items to be built into masonry. Consult with other trades in advance so their work can be accommodated at correct locations, as masonry work progresses, to avoid cutting and patching.

2. Cells containing anchorage or built-in items shall be grouted solid.

3. Where masonry is laid against concrete or metal, the joints between shall be filled with mortar as each course is laid.

L. Joint Finishing:

1. Pack mortar tightly in joints and wipe wall faces clean as work progresses. Unless otherwise indicated, exposed joints shall be densely tooled concave and smooth with joint tool when mortar is thumbprint hard.

2. Joints in work concealed by other finishes shall be cut or struck off flush. Rake out joints around metal frames in openings 3/4-inch deep for sealant to be applied under Section 07 90 00, Joint Protection.

3. Nominal joint size, both vertical and horizontal, shall be 3/8 inch.

M. Joining Work: Step back unfinished work for joining with new work. oothing shall be resorted to only where unavoidable. Before starting or resuming work, remove loose mortar and foreign matter from work in place, and clean all surfaces of work to be joined.

N. Control Joints: Provide control joints where indicated. Comply with TMS 402/602.

O. Precast Beams, Lintels, and Copings: Provide precast concrete units where indicated. Comply with TMS 402/602, and applicable requirements of Section 03 40 00, Precast Concrete.

3.02 REINFORCING STEEL

A. Provide reinforcing steel for grouted masonry as indicated. Comply with applicable requirements of TMS 402/602.

B. Vertical reinforcing bars shall be placed prior to laying the wall and shall be held in place by standard reinforcing supports. Vertical bars shall be held in position at top and bottom and at intervals not exceeding 190 diameters of the reinforcement or nine feet, whichever is less. Vertical reinforcing steel shall have a minimum clearance of one inch from the masonry.

C. When a foundation dowel does not line up with a vertical core, it shall not be sloped more than one horizontal in six vertical. Dowels shall be grouted into a core in vertical alignment, even though it is an adjacent cell to the vertical wall reinforcing.

D. Horizontal reinforcing bars for bond-beam or channel units shall be laid on the webs of the units in continuous masonry courses, and shall be solidly embedded in mortar and grout. Horizontal bars shall be tied to vertical bars as the block work progresses. Placing of horizontal reinforcing bars in mortar joints will not be permitted.

E. Reinforcing bars shall be straight except for bends around corners and where bends or hooks are indicated.

F. Reinforcing steel shall be lapped in accordance with TMS 402/602, Chapter 2 or Chapter 3. Length of lapped splices shall be not less than 30 bar diameters for bars in compression and 40 bar diameters for bars in tension. Lapped splice bars shall be wire-tied together for the entire length of the splice.

3.03 GROUTING

A. Grouting Requirements:

1. Cells of concrete unit masonry shall be filled solid with grout where indicated. Cells containing reinforcement and anchorage or built-in items shall be filled solid with grout. Comply with applicable requirements of TMS 402/602.

2. Spaces around metal frames and other built-in items shall be filled solid with grout or mortar.

3. Reinforcing steel shall be secured in place, inspected, and approved before grouting starts.

4. Mortar droppings and projections shall be kept out of the grout space. Webs, wythes, and reinforcement shall be cleaned of mortar droppings before grout is placed.

5. Grout shall be rodded, puddled, or vibrated in place.

6. Cells shall be filled solid with grout, and pours shall be stopped 1-1/2 inches below the top of a course to form a key at pour joints.

7. Grouting of beams over openings shall be performed in one continuous operation. Tops of unfilled cell columns under a horizontal masonry beam shall be covered with metal lath, or special units shall be used to confine the grout fill to the beam section.

8. Do not place pipes or conduits in any structural masonry, except that rigid electric conduit may be embedded in structural masonry when its location has been detailed on the structural Construction Drawings.

9. Do not form chases or recesses not shown on structural Constructional Drawings.

B. Grout Construction:

1. Grout construction, including grout placement and consolidation, shall conform with applicable requirements of TMS 402/602, except as otherwise specified herein.

2. Grout shall be placed in lifts not to exceed 4 feet, with a waiting period of one hour between lifts. The full height of the wall or masonry section shall be placed in one Day.

3. Rod or vibrate grout thoroughly the entire height of the pour when first placed to push grout into all spaces and interstices. A mechanical vibrator with a 3/4 inch to 1 inch head and low velocity shall be used. The vibrator shall be withdrawn slowly enough while on to allow the grout to close up the space that was occupied by the vibrator. After the waiting period of an hour, place second lift and rod or vibrate the pour again to penetrate not more than half way into the first lift. Repeat this placing operation, waiting period, and consolidating technique until the top is reached. The top pour or lift shall likewise be reconsolidated after waiting period to allow excess water to be absorbed and escape.

3.04 REPAIRING AND POINTING

A. Upon completion of the work, carefully examine masonry surfaces and cut out and replace broken or defective units. Rake out defective mortar joints and repoint.

3.05 CLEANING

A. After erection and pointing, masonry shall be cleaned down with stiff brushes and water, followed by a thorough rinsing with clean water. All mortar deposits, stains, or other foreign matter shall be removed from masonry surfaces.

B. After masonry has been fully grouted, laitance and stains that have percolated through the blocks and mortar joints shall be hosed off with water under pressure.

C. The Engineer may direct that certain masonry surfaces or areas be cleaned with a commercial masonry cleaner manufactured for the purpose, in which case follow the instructions or recommendations of the masonry-cleaner manufacturer for cleaning method.

3.06 CURING

A. Masonry work and top of the grout pour shall be damp-cured for at least seven Days to prevent too rapid drying during hot or drying weather, and drying winds.

B. Walls shall be kept moist or damp with water from a fogging nozzle, but shall not be wet to the point that free water drops from the surface.

3.07 SEALER APPLICATION

A. Preparation: Surfaces receiving sealer shall be thoroughly dry and free of all construction stains, surface dirt, and efflorescence.

B. Application: Apply sealer, where concrete unit masonry is exposed to the weather, in accordance with the manufacturer's application instructions and recommendations.

3.08 FIELD QUALITY CONTROL

A. Slump Tests: Perform slump tests of grout during grout placement in accordance with ASTM C1019 and ASTM C143/C143M.

B. Strength Tests: Provide laboratory tests conforming to the following requirements:

1. Concrete Masonry Units: Tensile strength tests shall be performed in accordance with ASTM C1006 and compressive strength test shall be performed in accordance with ASTM C140/C140M. Three units shall be tested for each 2,000 square feel of wall area.

2. Mortar: Compressive strength tests shall be performed in accordance with ASTM C109/C109M. Three cubes shall be tested for each 2,000 square feet of wall area, one at seven Days and two at 28 Days.

3. Grout: Compressive strength tests shall be performed in accordance with ASTM C1019. Three square prisms shall be tested for each 2,000 square feet, or fraction thereof, of wall area.

C. Test Reports: Submit certified copies of all test results to the Engineer for record purposes.

D. Rejection of Masonry; Repair and Replacement: The Engineer shall have authority to reject concrete masonry work that does not meet specification requirements, and to require repair or replacement as necessary to complete the concrete masonry work.

3.09 ACCEPTANCE OF STRUCTURE

A. Acceptance of the completed concrete masonry work requires conformance with the dimensional tolerances, appearance, and strengths specified in these Specifications and in TMS 402/602.

END OF SECTION 04 22 00

SECTION 05 05 22

METAL WELDING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Welding Rod/Electrodes.

B. Stud Shear Connectors.

C. Shop and Field Welding.

D. Inspections and Tests by the Contractor.

E. Inspections and Tests by the Engineer.

1.02 RELATED SECTIONS

A. Welding of H-piles and pipe shells for piles is specified in Section 31 62 00, Driven Piles.

B. Welding of reinforcing steel for concrete is specified in Section 03 20 00, Concrete Reinforcing.

C. Welding and brazing of piping for plumbing and mechanical systems are specified under the applicable Sections.

1.03 MEASUREMENT AND PAYMENT

A. Measurement: Welding and welds will not be measured separately for payment.

B. Payment: Welding and welds, including inspections and tests to be performed by the Contractor, will be paid for as part of the indicated Contract unit prices for the associated steel and metal work.

1.04 REFERENCES

A. American National Standards Institute (ANSI)/American Institute of Steel Construction (AISC):

1. ANSI/AISC 341 Seismic Provisions for Structural Steel Buildings

2. ANSI/AISC 360 Specifications for Structural Steel Buildings

B. American Society for Nondestructive Testing (ASNT):

1. SNT-TC-1A Recommended Practice: Personnel Qualification and Certification in Nondestructive Testing.

C. American Society for Testing and Materials (ASTM):

1.	ASTM E94/E94M	Standard Guide for Radiographic Examination Using Industrial Radiographic Film
2.	ASTM E164	Standard Practice for Contact Ultrasonic Testing of Weldments
3.	ASTM E165/E165M	Standard Practice for Liquid Penetrant Testing for General Industry
4.	ASTM E709	Standard Guide for Magnetic Particle Testing
5.	ASTM E1032	Standard Practice for Radiographic Examination of Weldments Using Industrial X-Ray Film

D. American Welding Society (AWS):

1.	AWS A2.4	Standard Symbols for Welding, Brazing and Nondestructive Examination
2.	AWS A3.0M/A3.0	Standard Welding Terms and Definitions, Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting and Thermal Spraying
3.	AWS A5	Welding Rods, Electrodes, and Filler Metals Series
4.	AWS B1.10M/B1.10	Guide for the Nondestructive Examination of Welds
5.	AWS B2.1/B2.1M	Specification for Welding Procedures and Performance Qualification
6.	AWS C5.4	Recommended Practices for Stud Welding
7.	AWS D1.1/D1.1M	Structural Welding Code – Steel
8.	AWS D1.2/D1.2M	Structural Welding Code – Aluminum
9.	AWS D1.3/D1.3M	Structural Welding Code – Sheet Steel
10.	AWS D1.4/D1.4M	Structural Welding Code –Steel Reinforcing Bars
11.	AWS D1.5M/D1.5	Bridge Welding Code
12.	AWS D1.8/D1.8M	Structural Welding Code – Seismic Supplement
13.	AWS D9.1M/D9.1	Sheet Metal Welding Code
14.	AWS D10.4	Recommended Practices for Welding Austenitic Chromium- Nickel Stainless Steel Piping and Tubing
15.	AWS QC1	Specification for AWS Certification of Welding Inspectors

1.05 REGULATORY REQUIREMENTS

A. In addition to the foregoing referenced standards, the regulatory requirements that govern the work of this Section include the following code:

1. California Code of Regulations, Title 24, Part 2, California Building Code.

2. California Occupational Safety and Health Administration (Cal/OSHA).

1.06 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures. For Shop Drawings and other submittals, employ the standard welding symbols of AWS A2.4 and the standard welding terms of AWS A3.0M/A3.0.

B. Welder Qualifications: Submit copies of qualification test records for each welder, welding operator, and tack welder to be employed in the work. Comply with requirements of AWS D1.1/D1.1M. For bridgework, comply with requirements of AWS D1.5M/D1.5. For seismic provisions, comply with requirement of AWS D1.8/D1.8M. For aluminum welders, comply with AWS D1.2/D1.2M. For pipe and tube, comply with requirements of AWS B2.1/B2.1M.

1. Submit welders identification marks (I.D.) for each welder along with qualifications.

C. Welding Procedure Specifications (WPS): Prior to commencement of welding, submit the procedure specifications that will be used for welding. The WPS shall contain all data indicated in AWS D1.1/D1.1M Annex P, and any other information necessary to produce welded joints in compliance with this specification. For procedures other than those prequalified in accordance with AWS D1.1/D1.1M, D1.2/D1.2M, D1.5M/D1.5, and D1.8/D1.8M, submit a copy of procedure qualification test records in accordance with the qualification requirements of AWS D1.1/D1.1M, AWS D1.2/D1.2M, AWS D1.5M/D1.5, and AWS D1.8/D1.8M as applicable. WPS shall also include the mitigation of corrosion of welds, including heat treatment and chemical compatibility, as applicable.

D. Welding Records and Data:

1. Submit all radiographs upon completion of fabrication.

2. Submit certifications that magnetic particle and dye-penetrant inspections have been satisfactorily completed.

3. Submit records of ultrasonic testing upon completion.

4. If field welding is permitted, submit descriptive data for field welding equipment.

E. Mill Certificates: Submit mill certificates and certified copy of reports for analyses and tests required by referenced ASTM and AWS specifications.

1.07 QUALITY CONTROL

A. Qualification of Welders and Welding Procedures: Welders, welding operators, tack welders, and welding procedures shall be prequalified or qualified in accordance with the following AWS Welding Codes and Standards:

1. Structural Steel: AWS D1.1/D1.1M, Section 4, Qualification. Includes steel for miscellaneous metalwork, steel stairs, and railings.

2. Stud Welding: AWS D1.1/D1.1M, Section 7.6, Stud Application Qualification Requirements.

3. Structural Aluminum: AWS D1.2/D1.2M, Section 3, Qualification.

4. Sheet Steel (Structural): AWS D1.3/D1.3M, Section 4, Qualification. Prequalification is not applicable to sheet steel.

5. Concrete Reinforcing Steel: AWS D1.4/D1.4M, Section 6, Qualification. Coordinate with requirements specified in Section 03 20 00, Concrete Reinforcing.

6. Steel for Bridges: AWS D1.5M/D1.5, Section 5, Qualification.

7. Seismic Supplement: AWS D1.8/D1.8M, Section 5, Welder Qualification.

8. Sheet Metal:

    a. Welders: AWS D9.1M/D9.1, Section 6, Qualification of Arc Welders and Arc Welding Operators, and Section 11, Qualification of Braze Welders and Braze Welding Operators.

    b. Welding Procedures: AWS D9.1M/D9.1, Section 5, Arc Welding Procedure Qualification, and Section 10, Braze Welding Procedure Qualification.

9. Pipe and Tube: AWS B2.1/B2.1M

B. Qualification of Welding Inspector: Welds to be inspected by the Contractor shall be inspected and certified by a Contractor-employed AWS Certified Welding Inspector (CWI), certified in accordance with AWS QC1.

C. Qualification of Personnel Performing Nondestructive Testing: Personnel performing nondestructive testing, who are Contractor-employed, shall be qualified and certified in accordance with SNT-TC-1A. Only persons certified for NDT Level I and working under a NDT Level II or III person or persons certified for NDT Level II or III may perform nondestructive testing.

D. Weldability of Steel: For structural steel requiring impact test qualification and for corrosion-resistant structural steel, the weldability of the steel and the procedures for welding it shall be established by qualification in accordance with AWS D1.1/D1.1M, Section 4.

E. Qualification of Stud-Connector Manufacturer: Stud shear connector manufacturer shall be qualified in accordance with AWS D1.1/D1.1M, Section 7.9, Manufacturers Stud Base Qualification Requirements.

F. Stud Welding Standards: For stud welding, comply with applicable requirements of AWS C5.4 for steel and stainless steel, and AWS D1.2/D1.2M, Section 6, for aluminum.

G. Moment-Resisting Frames: Welding of beam-to-column joint connections in moment-resisting frames shall conform with ANSI/AISC 341, ANSI/AISC 360, and AWS D1.8/D1.8M.

H. Iron Contamination of Stainless Steel: Iron contamination of stainless steel will not be accepted. Welds shall be ground smooth and polished at the factory to blend in with the surrounding finish surfaces. Refer also to Section 05 70 00, Decorative Metal, for requirements.

PART 2 – PRODUCTS

2.01 WELDING ROD/ELECTRODES

A. Electrodes for structural plate, shapes, pipe, tubes, and bars shall conform with AWS A5 Series Standards and shall be coated rods or wire of size and classification number as recommended by their manufacturers for the positions and other conditions of actual use. Matching filler metal requirements shall conform with AWS D1.1/D1.1M, AWS D1.5M/D1.5 and AWS D1.8/D1.8M, as applicable.

B. Electrodes for sheet steel shall conform with AWS A5 Series Standards and shall be coated rods or wire of size and classification number as recommended by their manufacturers for the positions and other conditions of actual use. Matching filler metal requirements shall conform with AWS D1.3/D1.3M.

C. Welding electrodes and welding rods for stainless steel shall conform with AWS A5.4 and AWS A5.9 as recommended by their manufacturers for the positions and other conditions of actual use. Matching filler metals shall be compatible with the Type 316 or Type 304 stainless steel, as applicable.

D. Electrodes for aluminum shall conform with AWS A5.10 and AWS A5 Series Standards and shall be coated rods or wire of size and classification number as recommended by their manufacturers for the positions and other conditions of actual use. Matching filler metal requirements shall conform with AWS D1.2/D1.2M.

2.02 STUD SHEAR CONNECTORS

A. Only products of manufacturers qualified in accordance with AWS D1.1/D1.1M, will be accepted for this work.

2.03 SHOP WELDING

A. Perform shop welding as indicated in accordance with the California Building Code, AWS D1.1/D1.1M, AWS D1.2/D1.2M, AWS D1.3/D1.3M, AWS D1.5M/D1.5, AWS D1.8/D1.8M and AWS D9.1M/D9.1, as applicable to the work.

B. Welders shall mark adjacent to completed welds their welder I.D., using metal stamp, metal engraving, keel, paint stick, or other appropriate marking material.

C. Welding of stud shear connectors shall conform with AWS D1.1/D1.1M, Section 7, Stud Welding, AWS C5.4, Practices for stud welding and the stud manufacturer's instructions.

D. Welding of stainless steel pipe and tube shall conform with applicable requirements of AWS D10.4.

E. All groove welds shall be complete penetration welds unless otherwise indicated.

2.04 INSPECTIONS AND TESTS BY THE CONTRACTOR

A. Testing and Inspection: Testing and Inspection of welds shall proceed 24 hours after the completion of welding unless the Engineer has approved for a later time.

B. Visual Inspection: All welds shall be visibly examined in accordance with AWS D1.1/D1.1M, AWS D1.5M/D1.5, and AWS D1.8/D1.8M, as applicable. Quality of welds and standards of acceptance shall be in accordance with AWS D1.1/D1.1M and AWS D1.5M/D1.5.

C. Nondestructive Testing: Nondestructive testing shall conform with AWS B1.10M/B1.10.

D. Radiographic Testing: Radiographic testing of welds shall conform with AWS D1.1/D1.1M, AWS D1.5M/D1.5 and ASTM E94, and ASTM E1032, as applicable. Complete joint penetration groove welds shall be tested as follows:

1. 10 percent with thickness equal to or less than 3/4 inch.

2. 50 percent with thickness greater than 3/4 inch and equal to or less than 1-1/2 inches.

3. 100 percent for thickness greater than 1-1/2 inches.

E. Ultrasonic Testing: Ultrasonic testing of welds shall conform with AWS D1.1/D1.1M, AWS D1.5M/D1.5 and ASTM E164, as applicable. Complete joint penetration groove welds not accessible for radiographic testing shall, with Engineer's approval, be subjected to ultrasonic testing. The extent shall be the same as specified for radiographic testing.

F. Magnetic Particle Inspection: Magnetic particle inspection of welds shall conform with ASTM E709. Complete and partial joint penetration groove welds and fillet welds shall be inspected as follows:

1. 20 percent of complete joint penetration groove welds of tee and corner joints.

2. 10 percent of partial joint penetration groove welds and fillet welds.

G. Liquid Penetrant Inspection: Liquid dye penetrant inspection of welds shall conform with ASTM E165/E165M. Liquid penetrant inspection shall be used for detecting discontinuities that are open to the surface.

H. Test Results: Test result information shall be forwarded to the Engineer immediately after test results are available, stating the acceptance or rejection of fabricated components, so that repairs and reinspection or testing may be performed as soon as possible.

I. Testing for Unacceptable Welds: If the herein specified testing or inspection indicated any failure weld or resulted in any unacceptable weld, the Contractor has to perform the same testing or inspection on a separate batch of welds other than the batches that were tested. This process shall be repeated until all welds in the same batch have passed the testing or inspection and are acceptable by the Engineer.

J. Repairs: Unacceptable welds shall be repaired in accordance with AWS D1.1/D1.1M, AWS D1.5M/D1.5, and AWS D1.8/D1.8M, as applicable. Repaired or corrected welds shall be reinspected or retested as specified for the original weld.

2.05 INSPECTIONS AND TESTS BY THE ENGINEER

A. All welds are subject to inspections and tests by the Engineer as specified herein. Welds to be inspected and tested by the Engineer will be selected at random.

B. The Engineer will make test results available to the Contractor.

PART 3 – EXECUTION

3.01 FIELD WELDING

A. Field welding, where indicated or permitted by the Engineer, shall be performed as herein specified for shop welding and comply with CAL/OSHA requirements. The Contractor shall identify a risk for fire damage and maintain a fire watch during the work as approved by the Engineer.

3.02 INSPECTIONS AND TESTS

A. The Contractor shall perform inspections and tests of field welds as herein specified for shop welds.

B. The Engineer reserves the right to perform inspections and tests of field welds as herein specified for shop welds.

3.03 CLEANING

A. Welds shall be cleaned in accordance with AWS D1.1/D1.1M.

B. Welds of stainless steel shall be cleaned in accordance with Section 05 70 00, Decorative Metal, Article 3.02, Cleaning of Stainless Steel, and shall be protected from damage and corrosion at the factory, during shipping, and at the jobsite until acceptance of the work by the Engineer.

C. All other cleaning requirements shall be in accordance with Section 01 74 14, Cleaning.

END OF SECTION 05 05 22

SECTION 05 12 00

STRUCTURAL STEEL FRAMING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Structural Steel for Bridges.

B. Structural Steel for Buildings and Other Structures.

C. Structural Tubing.

D. Pipe.

E. Steel Pins.

F. Anchors and Fasteners.

G. Stud Shear Connectors.

H. Forgings.

I. Castings.

1.02 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for structural steel will be either by the lump-sum method or by the unit-price method as determined by the listing of the bid item for structural steel indicated in the Bid Schedule of the Bid Form.

B. Lump Sum: If the Bid Schedule indicates a lump sum for structural steel, the lump-sum method of measurement and payment will be in accordance with Section 01 20 00, Price and Payment Procedures, Article 1.03.

C. Unit Price: If the Bid Schedule indicates a unit price for structural steel, the unit-price method of measurement and payment will be as follows:

1. Measurement:

a. Structural steel will be measured for payment by the pound or by the ton, calculated without deduction for holes under 12 inches in longest dimension, for each item, type, and grade of structural steel installed complete in place. Weights will be calculated in accordance with AISC “Code of Standard Practice for Steel Buildings and Bridges”.

b. Stud shear connectors, shims, wedges, fasteners, shop and field touchup painting, and non-shrink grout for base or bearing plates will not be measured separately for payment. All costs in connection therewith will be considered incidental to and included with the applicable items of structural steelwork.

2. Payment: Structural steel will be paid for at the indicated Contract unit prices for the computed quantities as determined by the measurement method specified in Article 1.02.C.1.

1.03 REFERENCES

A. American National Standards Institute (ANSI)/American Institute of Steel Construction (AISC):

1. AISC Steel Construction Manual
2. ANSI/AISC 303 Code of Standard Practice for Steel Buildings and Bridges
3. AISC RCSC Specifications for Structural Joints Using High-Strength Bolts
4. ANSI/AISC 341 Seismic Provisions for Structural Steel Buildings
5. ANSI/AISC 360 Specifications for Structural Steel Buildings
6. AISC 348 Specification for Structural Joints Using High-Strength Bolts

B. American Railway Engineering and Maintenance of Way Association (AREMA):

1. Manual for Railway Engineering (Fixed Properties), herein referred to as the "AREMA Manual", Chapter 15, "Steel Structures"

C. American Society for Testing and Materials (ASTM):

1. ASTM A6/A6M Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling
2. ASTM A27/A27M Standard Specification for Steel Castings, Carbon, for General Application
3. ASTM A36/A36M Standard Specification for Carbon Structural Steel
4. ASTM A47/A47M Standard Specification for Ferritic Malleable Iron Castings
5. ASTM A48/A48M Standard Specification for Gray Iron Castings
6. ASTM A53/A53M Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
7. ASTM A108 Standard Specification for Steel Bars, Carbon and Alloy, Cold-Finished
8. ASTM A148/A148M Standard Specification for Steel Castings, High-Strength, for Structural Purposes

9. ASTM A153/A153M	Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
10. ASTM A194/A194M	Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
11. ASTM A242/A242M	Standard Specification for High-Strength Low-Alloy Structural Steel
12. ASTM A307	Standard Specification For Carbon Steel Bolts, Studs, and Threaded Rod 60,000 psi Tensile Strength
13. ASTM A370	Standard Test Methods and Definitions for Mechanical Testing of Steel Products
14. ASTM A449	Standard Specification for Hex Cap Screws, Bolts and Studs, Steel, Heat Treated, 120/105/90 ksi Minimum Tensile Strength, General Use
15. ASTM A500/A500M	Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
16. ASTM A501/A501M	Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing
17. ASTM A514/A514M	Standard Specification for High-Yield-Strength, Quenched and Tempered Alloy Steel Plate, Suitable for Welding
18. ASTM A563	Standard Specification for Carbon and Alloy Steel Nuts
19. ASTM A572/ A572M	Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
20. ASTM A588/ A588M	Standard Specification for High-Strength Low-Alloy Structural Steel up to 50 ksi (345 MPa) Minimum Yield Point with Atmospheric Corrosion Resistance
21. ASTM A618/A618M	Standard Specification for Hot-Formed Welded and Seamless High-Strength Low-Alloy Structural Tubing
22. ASTM A668/ A668M	Standard Specification for Steel Forgings, Carbon and Alloy, for General Industrial Use
23. ASTM A673/A673M	Standard Specification for Sampling Procedure for Impact Testing of Structural Steel
24. ASTM A709/A709M	Standard Specification for Structural Steel for Bridges
25. ASTM D4285	Standard Test Method for Indicating Oil or Water in Compressed Air

26. ASTM F436/F436M Standard Specification for Hardened Steel Washers Inch and Metric Dimensions

27. ASTM F959/F959M Standard Specification for Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners, Inch and Metric Series

28. ASTM F3125/F3125M Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, Inch Dimensions 120 ksi and 150 ksi Minimum Tensile Strength, and Metric Dimensions 830 MPa and 1040 MPa Minimum Tensile Strength

29. ASTM A123/A123M Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

30. ASTM A143/A143M Standard Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement

31. ASTM A384/A384M Standard Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies

32. ASTM A385 Standard Practice for Providing High-Quality Zinc Coatings (Hot-Dip)

33. ASTM A780 Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings

34. ASTM A992/A992M Standard Specification for Structural Steel Shapes

35. ASTM A1085/ A1085M Standard Specification for Cold-Formed Welded Carbon Steel Hollow Structural Sections (HSS)

36. ASTM D6386 Standard Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Painting

D. American Welding Society (AWS):

1. AWS A2.4 Standard Symbols for Welding, Brazing and Nondestructive Examination

2. AWS D1.1/D1.1M Structural Welding Code – Steel

3. AWS D1.5M/D1.5 Bridge Welding Code

E. The Society for Protective Coatings (SSPC):

1. SSPC-SP 1 Solvent Cleaning

2. SSPC-SP 3 Power Tool Cleaning

3.	SSPC-SP 6/NACE No. 3	Commercial Blast Cleaning
4.	SSPC-SP 10/NACE No. 2	Near-White Blast Cleaning
5.	SSPC-SP 11	Power Tool Cleaning to Bare Metal
6.	SSPC-PA 1	Shop, Field, and Maintenance Painting of Steel
7.	SSPC-Paint 20	Zinc-Rich Coating (Type I – Inorganic and Type II – Organic)
8.	SSPC-Paint 42	Epoxy Polyamide/Polyamidoamine Primer, Performance-Based

1.04 REGULATORY REQUIREMENTS:

A. The regulatory requirements which govern the work of this Section include the following governing code:

California Code of Regulations (CCR), Title 24, Part 2, California Building Code, Chapter 22, “Steel”, and Chapter 22A, “Steel”.

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings:

1. Submit detailed Shop Drawings of structural steel work prior to fabrication, showing sizes, details of fabrication and construction, methods of assembly, locations of hardware, anchors, and accessories, and erection sequence and details. Include procedures for heavy lifts and rigging. Erection drawings shall be referenced to the Contract Drawings.

2. Shop Drawings shall include member identity, welding technique, cuts, copes, gussets, connections, holes, fasteners, camber, fabrication and erection tolerances, type of finish, paint system, weights of members, and critical clearances.

3. Welds, both shop and field, shall be indicated by standard welding symbols of AWS A2.4. Drawings shall show the size, length, and type of each weld.

    a. Indicate individual welders’ identification (I.D.) on project record drawings.

4. Investigate stresses caused by the proposed erection procedure. Submit drawings showing details of required temporary supports, staying, and bracing. Include descriptive data and design calculations, to illustrate the erection, transportation, and handling procedures, including sequence of erecting and transfer of loads if applicable.

5. Furnish setting diagrams, templates, and directions for the erection of structural framing, anchor bolts, bearing plates, and other embedded items.

6. The Contractor shall be responsible for errors of fabrication and for correct fitting of structural members.

C. Detailing Requirements: Requirements for the detailing of structural steel work are specified herein under Part 2 – Products because of the close relationship of detailing with fabrication requirements.

D. Product Data: Submit manufacturer's product data of load-indicator washers (Compressible-Washer-type direct tension indicators) when proposed for use.

E. Mill Test Reports:

1. Submit certified mill test reports of structural steel materials, covering chemical analysis and physical properties of each heat of steel from which the material for structural steel will be furnished, in conformance with the hereinafter specified ASTM Specifications.

2. Steel materials which are not properly certified as conforming with specified ASTM Specifications will be rejected.

F. Welding Records and Data: Refer to Section 05 05 22, Metal Welding, for requirements.

1.06 QUALITY ASSURANCE

A. Fabricator's Shop or Facility: Fabricator's shop or facility will be inspected and approved by the Engineer before the start of fabrication work. Notify the Engineer in writing at least ten Days before the scheduled start of fabrication work. Fabrication of structural steel shall be performed by an approved fabricator at an approved facility.

B. Indicated Dimensions: Unless otherwise indicated, dimensions at expansion joints and similar construction were determined for a temperature of 50 degrees Fahrenheit. Make proper adjustments for temperature when the structure is to be fabricated and installed at any other temperature.

C. Tolerances:

1. Variation of camber from indicated dimensions:

a. Structural rolled beams directly supporting bridge deck: minus zero, plus 1/2 inch for beams 50 feet and shorter, with an additional tolerance of plus 1/8 inch for each ten feet or fraction thereof in excess of 50 feet.

b. Welded plate girders: Conform with requirements of AWS D1.1/D1.1M, Article 5.22, Dimensional Tolerance of Welded Structural Members.

2. Measure camber with beam or girder in a no-load position (laid on its side).

D. Calibration of Torque Wrenches:

1. The calibrating device for setting calibrated torque wrenches shall be checked for accuracy by the Contractor's qualified personnel not more than 30 Days prior to its first use on the work, and at intervals not more than six months thereafter.

2. If the Engineer has reason to question the accuracy of the calibrating device, the Engineer may require that it be returned to the manufacturer for certification of its accuracy.

3. Calibrate torque wrenches as specified in AISC 348.

E. Qualifications of Welders and Welding Procedures: Refer to Section 05 05 22, Metal Welding, for requirements.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Avoid bending, scraping, and overstressing the steelwork. Block with wood, or otherwise protect, projecting parts which may be bent or damaged.

B. Mark weight and piece (mark) number, corresponding to shop erection sequence drawing, on all members. Match-mark all shop pre-fitted members. Use low-stress stamps for fracture critical members and tension members.

C. Ship small parts, such as bolts, nuts, washers, pins, fillers, clips, and small connecting plates and anchors, in boxes, crates, or barrels. Pack separately each length and diameter of bolt and each size of nut and washer. Plainly mark an itemized list and description of the contents on the outside of each container.

D. Load, transport, unload, and store structural steel materials in such a manner that the metal is kept clean and free from injury. Store materials above ground on platforms, skids, or other supports, and cover and protect from corrosion.

E. Handle and store beams and girders in such a manner that they will have the required camber after erection.

PART 2 – PRODUCTS

2.01 MATERIALS

A. General: Manufactured steel clips and angles will be accepted where such will meet the requirements of the Contract Documents and are shown on the Shop Drawings.

B. Structural Steel for Bridges: ASTM A709/A709M, Grade 36, 36T2, 50T2, or 50WT2, as indicated.

1. Identify all materials by heat and lot, if applicable. Correlate with certified mill test reports.

2. Impact Test Qualification: Specific test requirements for Charpy impact testing for grades 36T2, 50T2, and 50WT2 shall be as follows:

    a. Sampling and Testing Procedures: ASTM A370 and ASTM A673/A673M, as applicable.

    b. Frequency of Testing: H.

    c. Test Temperature: 40 degrees Fahrenheit.

    d. Condition of Material: As-rolled.

    e. Orientation of Test Bars: Longitudinal to the direction of final rolling.

    f. Absorbed Energy Requirements:

        1) Normal-strength steel to four inches thick and high-strength steel to two inches thick for welded construction and to four inches thick for bolted construction: 15 ft-lbf.

        2) High-strength steel, two inches to four inches thick, for welded construction: 20 ft-lbf.

        3) Subsize Specimens: 12.5 ft-lbf for ten mm by 7.5 mm specimens, and ten ft-lbf for ten mm by five mm specimens.

C. Structural Steel for Buildings and Other Structures:

1. Structural Steel: ASTM A572/A572M, ASTM A992/A992M, Grade 50, or ASTM A36/A36M

2. High-Strength Steel: ASTM A242/A242M, A572/A572M or A588/A588M, grade or type as indicated.

3. High-Strength Plate for Welding: ASTM A514/A514M.

4. Impact Tests: For rolled shapes of ASTM A6/A6M Groups 4 and 5, shapes built-up by welding plates two inches thick or thicker, and supplied weld filler metals subject to tensile stresses, shall be furnished with Charpy V-notch testing in accordance with ASTM A6/A6M, Supplementary Requirements, S5. Charpy impact testing shall be in accordance with ASTM A370 and A673/A673M and as specified herein.

D. Structural Tubing:

1. Cold-Formed Carbon Steel: ASTM A500/A500M, Grade B or as indicated.

2. Hot-Formed Carbon Steel: ASTM A501/A501M, minimum yield point of 36,000 psi.

3. High-Strength, Low-Alloy Steel: ASTM A618/A618M, Grade as indicated.

4. Cold-Formed Carbon Steel for Bridges: ASTM A1085/A1085M

E. Pipe: ASTM A53/A53M, Type E or Type S, Grade B (minimum yield point of 35,000 psi).

F. Steel Pins:

1. Greater than nine inches in diameter: ASTM A668/A668M, Class B, C, or D.

2. Nine inches and less in diameter: ASTM A668/A668M, Class B, C, or D, or ASTM A108, Grades 1016 through 1030.

G. Anchors and Fasteners:

1. Anchors, Bolts, Nuts, and Washers: Bolts and studs, nuts, and washers shall conform with ASTM A307, Grade A, and ASTM A449, A563, and F436/F436M, as applicable. Bolts and studs, nuts, and washers shall be hot-dip galvanized in accordance with ASTM A153/A153M, except bolts, nuts, and washers for structural steel shall be machined items without protective coatings.

2. High-Strength Bolted Connections: Slip-critical type, high-strength bolts. All other threaded fasteners: Furnished with locking hardware.

3. High-Strength Carbon Steel Bolts: ASTM F3125/F3125M, Type 1; except provide Type 3 for corrosion-resistant steel.

4. High-Strength Alloy Steel Bolts: ASTM F3125/F3125M, Type 1; except provide Type 3 for corrosion-resistant steel.

5. Heavy-Duty Hardened Hex Nuts and Washers:

   a. Nuts:

      1) For Type 1 Bolts: ASTM A194/A194M, Grade 2H, or ASTM A563, Grade DH.

      2) For Type 3 Bolts: ASTM A563, Grade C3 or DH3.

   b. Washers: ASTM F436/F436M, for use with ASTM F3125/F3125M bolts, as applicable.

6. Load-Indicator Washers: ASTM F959, for use with ASTM F3125/F3125M bolts, as applicable.

7. Lubricant for Bolts: Molybdenum disulfide base.

H. Stud Shear Connectors:

1. Stud connectors shall be produced by cold heading, cold rolling, or cold machining. Finished stud connectors shall be uniform quality and free of injurious laps, fins, seams, cracks, twists, bends, or other defects. Studs shall not have cracks or bursts deeper than one-half the thickness from the periphery of the head to the shaft. Tensile strength of stud connectors shall be determined by tests of bar stock after drawing or of full diameter finished studs. Strength requirements shall conform to the following:

Tensile Strength (min.)	Elongation (min.)	Reduction of Area (min.)
60,000 psi	20 percent in 2 inches	50 percent

2. Stud connectors shall be furnished with arc shields (ferrules) of heat-resistant ceramic or other suitable material for welding.

I. Forgings: ASTM A668/A668M, Class C for carbon steel and Class G for alloy steel.

J. Castings:

1. High-Strength Steel: ASTM A148/A148M, grade as indicated.

2. Mild-to-Medium-Strength Carbon Steel: ASTM A27/A27M, grade as indicated.

3. Malleable Iron: ASTM A47/A47M, Grade 35018.

4. Gray Iron: ASTM A48/A48M, Class 30B.

K. Welding Electrodes: Refer to Section 05 05 22, Metal Welding, for requirements.

L. Open-Web Steel Joists: Refer to Section 05 21 00, Steel Joist Framing, for requirements.

M. Shop Painting Materials: As herein specified under Article 2.04.

N. Grout: Provide high-strength, non-shrink grout for base plates in accordance with the requirements of Section 03 61 11, Non-Shrink Grout.

2.02 DETAILING REQUIREMENTS

A. Detailing Standards:

1. Except as specified otherwise herein or as indicated otherwise on the Contract Drawings, detailing and tolerances shall conform with applicable requirements of AISC Steel Construction Manual, ANSI/AISC 360 and ANSI/AISC 303.

2. Special seismic detailing provisions shall conform with ANSI/AISC 341.

3. Items to be galvanized shall be detailed as specified in Section 05 50 00, Metal Fabrications.

B. Required Provisions:

1. All working points indicated on the Contract Drawings shall be adhered to in the detailing of the work.

2. Substitutions of sections shall be made only as approved by the Engineer.

3. Provide holes required for securing other work to structural steel framing, and for passage of other work through steel framing members.

4. Detail and fabricate work with suitable drain and vent holes as required to provide positive drainage and to prevent the trapping of moisture and stagnant air.

C. Connections:

1. Connections shall be as indicated and as specified herein.

2. Furnish all bolts and bolt placement lists for field and shop connections, including all temporary carbon steel erection bolts and clips required for field erection.

3. Except as otherwise indicated, all connections shall be shop welded and field bolted. Field welded connections will be permitted only where indicated on the Contract Drawings or where specifically approved by the Engineer in writing.

4. Bolted connections shall be made with 3/4 inch or 7/8 inch diameter bolts as specified in ASTM F3125/F3125M, unless otherwise indicated. Tapered washers shall be provided on bolted connections to channels and other structural shapes with sloping flanges.

5. Framed beam connections which are not detailed or otherwise indicated shall be shop welded and field bolted in accordance with AISC Steel Construction Manual, ANSI/AISC 341 and ANSI/AISC 360.

6. Detail field splice connections to develop the full strength of the section in which the splice is made.

7. All joints made with high strength bolts shall be considered to be bearing-type connections with threads included in the plane of shear, except moment-resisting joints and connection joints where slip-critical type high-strength bolts are required.

2.03 FABRICATION

A. Structural steelwork shall conform with the applicable requirements of the California Building Code, ANSI/AISC 341 and ANSI/AISC 360. Structural steelwork for railroad and transit rail bridges shall conform with applicable requirements of the AREMA Manual.

B. Welding and welded connections shall conform with the requirements of Section 05 05 22, Metal Welding.

C. Steel members and metal fabrications shall be prefabricated and preassembled in the factory or shop as far as practicable.

D. Form and fabricate the work to meet installation conditions. Include accessories to adequately secure the work in place.

E. Cutting, drilling, punching, and welding shall be neatly performed with burrs and rough edges removed. Remove all weld flux.

F. Straighten rolled material, if necessary, before it is laid out for fabrication, in a manner conforming to the mill tolerances specified in ASTM A6/A6M, and by a process and in a manner which will not injure the material. Sharp kinks and bends will be cause for rejection of the material. Heat shrinking of low-alloy structural steel will not be permitted.

G. Perform shearing, flame cutting, and chipping carefully and accurately so as not to induce residual stress in the metal being cut. The radii of re-entrant gas-cut fillets shall be not less than 3/4 inch and as much larger as practicable. Perform flame cutting in such manner that metal being cut is not carrying stress. Cut edges exposed in the finished work shall be machine cut, sheared, or flame cut, and ground flush. All working points shall be maintained.

H. Fabricate bearing stiffeners and stiffeners intended as supports for concentrated loads as indicated. Mill or grind bearing surfaces of these stiffeners.

I. Bend load-carrying cold-rolled steel plates cold at right angles to the direction of rolling. The radius of bend, measured to the concave face of the metal, shall be not less than indicated in the following table, in which T is the thickness of the plate.

Angle Through Which Plate is Bent	Minimum Radius
61 to 120 degrees	1.0 T
121 to 150 degrees	2.0 T

1. If a shorter radius is indicated, bend the plate hot. Before bending, round plate edges, where bending occurs, to a radius of 1/16 inch.

J. Connections shall be bolted or welded as indicated.

K. Holes shall be drilled or punched at right angles to the surface of the metal and shall not be made or enlarged by burning. Holes in base or bearing plates shall be drilled. Holes shall be provided in members to permit connecting the work of other trades. Holes shall be punched or drilled at 1/16 inch larger than the diameter of the bolt.

L. For high-strength bolting, assemble joints and install bolts in accordance with AISC 348. Hardened-face washers shall be used for all connections using ASTM F3125/F3125M bolts. Assembly of joints using load-indicator washers shall conform to ASTM F959. High-strength bolting will be inspected by a qualified inspector employed by the Contractor’s testing laboratory.

M. For items bearing on concrete, provide steel bearing plates and anchors as indicated. Base or bearing plates shall be leveled by means of adjustment nuts. Templates shall be furnished, together with instructions for setting of anchors, anchor bolts, and bearing plates. Contractor shall assure that anchors and related items are properly set in concrete during the progress of the work.

N. Fabricate metal bearing surfaces which will come in contact with preformed elastomeric bearing pads or grout, flat to within 1/8 inch tolerance in 12 inches and to within 3/16 inch overall.

O. Include reinforcing angles, clip angles, plates, punched straps, brackets, and hangers as required to complete the work as indicated.

P. Provide drainage holes in structural components where water may accumulate without escape.

Q. Fabricate architecturally exposed structural steel members straight within one-half of the standard camber and sweep tolerances permitted by ASTM A6/A6M.

2.04 CLEANING AND PAINTING

A. Interior, Non-Corrosive Applications:

1. After fabrication and immediately before shop painting, structural steel materials shall be washed with solvent to remove dust and residue in accordance with SSPC-SP 1.

    a. Structural steel materials not exposed to the public shall be power-tool cleaned in accordance with SSPC-SP 3 to remove mill scale, rust, grease, oil, and any other foreign matter.

    b. Structural steel materials exposed to public view shall be blast cleaned in accordance with SSPC-SP 10/NACE No. 2 or power-tool cleaned in accordance with SSPC-SP 11 to remove all visible mill scale, rust, grease, oil, and any other foreign matter.

2. If materials are not painted immediately after cleaning then those materials shall be washed with solvent to remove dust and residue in accordance with SSPC-SP 1.

3. After preparation, steel materials shall be shop painted with one coat of corrosion-inhibitive metal primer in accordance with SSPC PA 1. Materials and application shall conform with SSPC-Paint 20 or SSPC-Paint 42.

B. Exterior Applications:

1. Steelwork to be exposed to weather shall be blast cleaned in accordance with SSPC-SP 10/NACE No.02, Near-White Blast Cleaning, or power-tool cleaned in accordance with SSPC-SP 11, Power Tool Cleaning to Bare Metal. For new steel bridges, cleaning shall be in accordance with SSPC-SP 10/NACE No. 2.

2. After cleaning, solvent wash in accordance with SSPC-SP 1, and shop paint steelwork in accordance with SSPC-PA 1. Materials and application shall conform with SSPC-Paint 20, Zinc-Rich Coatings, Type I – Inorganic or Type II – Organic. For new steel bridges, only shop-applied Type I – Inorganic Zinc Rich Primers shall be used.

3. Where steel components are indicated to be galvanized, comply with galvanizing requirements of Section 05 50 00, Metal Fabrications.

    a. Galvanized components shall be prepared and painted in accordance with the requirements for cleaning and painting in Section 05 50 00, Metal Fabrication.

C. Steel Materials to Receive Spray-Applied Fireproofing:

1. Steel materials shall be power-tool cleaned in accordance with SSPC-SP 3 to remove mill scale, rust, grease, oil, and any other foreign matter. Welds shall thoroughly wire brushed.

2. After cleaning and just before delivery of steel to the jobsite, steel materials shall be washed with solvent to remove dust and residue in accordance with SSPC-SP 1.

3. Steel materials to receive spray-applied fireproofing shall be shop painted with a primer if recommended by the manufacturer of the fireproofing material, and the primer shall be approved by the manufacturer of the fireproofing material.

D. Steel Materials to Receive Intumescent Fireproofing:

1. Interior steel materials shall be power-tool cleaned in accordance with SSPC-SP 3 to remove mill scale, rust, grease, oil, and any other foreign matter. Welds shall be thoroughly wire brushed.

2. Exterior steel materials shall be blast cleaned in accordance with SSPC-SP 6/NACE No. 3 to remove visible mill scale, rust, grease, oil, and any other foreign matter. After cleaning and just before delivery of steel to the jobsite, steel materials shall be washed with solvent to remove dust and residue in accordance with SSPC-SP 1.

3. Primer to be shop applied shall be as recommended and approved by the manufacturer of the intumescent fireproofing material, and evidence of such approval shall be submitted to the Engineer for review.

2.05 GALVANIZING

A. Steel and ferrous metal items on the exterior of buildings, items exposed to the weather and moisture, gratings, and items specifically indicated, shall be galvanized after fabrication by the hot-dip process in accordance with ASTM A123/A123M. Weight of the zinc coating shall conform to the requirements specified under “Weight of Coating” in ASTM A123/A123M. Provide high-quality galvanizing in conformance with ASTM A385.

1. Seal-weld Overlapping Surfaces: Remove weld flux. Plug vents provided in seal-welded overlapping surfaces to prevent entry of pickling acids. Remove such plugs before galvanizing.

B. Safeguarding against steel embrittlement shall conform to ASTM A143/A143M.

C. Safeguarding against warpage and distortion of steel members shall conform to ASTM A384/A384M.

D. Bolts and screws for attachment of galvanized items shall be galvanized in accordance with ASTM A153/A153M.

PART 3 – EXECUTION

3.01 ERECTION AND INSTALLATION

A. Reference Standards: Erection and installation of structural steel shall conform with the applicable requirements of AISC 303 and ANSI/AISC 360. Erection and installation of structural steel for railroad and transit rail bridges shall conform with applicable requirements of the AREMA Manual.

B. Lines and Levels: Structural steel shall be installed accurately at established lines and levels. Steel shall be plumb and level before bolting is commenced. Installation shall be in accordance with accepted Shop Drawings and actual conditions, true and horizontal or perpendicular as the case may be, level and square, with angles and edges parallel with related lines of the building or structure.

C. Temporary Bracing: Temporary bracing shall be provided as required and shall be kept in position until final completion. Shop fabricated items subject to damage shall be braced and carefully handled to prevent distortions or other damage. All items installed before concrete is placed shall be properly braced to prevent distortion by pressure of concrete. Bracing shall be watched and maintained by the Contractor during concreting operations.

D. Anchors, Anchor Bolts, Studs, and Fasteners:

1. Shop connections shall be welded and field connections bolted, unless indicated otherwise. Use washers under bolt heads and nuts to give full grip when nuts are turned tight. Use beveled washers where bolts bear on sloping surfaces.

2. Anchors, bolts and washers, inserts, studs, and fasteners as required for the erection, installation, and completion of the work, and other miscellaneous steel or iron fastenings to be installed in forms before concrete placement, or built into concrete, shall be provided as indicated at the time scheduled for this work.

3. Bolts and anchors shall be preset by the use of templates or such other methods as may be required to locate the anchors and anchor bolts accurately.

E. Bases and Bearing Plates: Bases and plates which require grouting shall be supported at the correct level by means of adjustment nuts on anchor bolts. Bases and plates shall be set accurately using a high-strength, non-shrink grouting mortar as specified in Section 03 61 11, Non-Shrink Grout.

F. Erection and Assembly:

1. After erection and field assembly, the various members forming parts of the completed structure shall be aligned and adjusted accurately before being fastened. Tolerances shall conform with the applicable requirements of AISC 303.

2. Fastening of splices of compression members shall be performed after the abutting surfaces have been brought into contact. Bearing surfaces and surfaces which will be in permanent contact shall be cleaned before the members are assembled. Splices will be permitted only where indicated.

3. Unless removal is required, erection bolts used in welded construction may be tightened securely and left in place. If erection bolts are removed, the holes shall be filled with plug welds and ground smooth. Poor matching of holes shall be corrected by drilling to the next larger size and providing the next larger size bolt. Welding for redrilling will not be permitted.

4. For moment-resisting joints with flanges or combined flange-reinforcing plates 1-1/2 inches thick or thicker, web bolts shall not be tightened past snug-tight until after completion of joint penetration welds.

G. Driftpins: Driftpins may be used only to bring together the several parts or components. Fit-up bolts and driftpins shall not be used to bring out-of-tolerance fabricated members and components into alignment. Driftpins shall not be used with such force as to distort or damage the material.

H. Gas Cutting: The use of a gas-cutting torch in the field for correcting fabrication errors will not be permitted.

I. Bolting:

1. Bolts shall be driven accurately into holes without damaging the thread. Bolt heads shall be protected from damage during driving. Washers shall be placed under all bolt heads and nuts. Bolt heads and nuts shall rest squarely against the washers.

2. Where bolts are to be used on beveled surfaces having slopes greater than one in 20 with a plane normal to the bolt axis, beveled washers shall be provided to give full bearing to the head or nut. Bolt threads shall be upset or spoiled to prevent the nuts from backing off.

3. Bolts transmitting shear shall be threaded to such a length that not more than one thread will be within the grip of the metal.

4. Bolts shall extend through but not more than 1/4-inch beyond the nuts, unless otherwise indicated. Bolt heads and nuts shall be drawn tight against the work with a suitable wrench not less than 15 inches long. Bolt heads shall be tapped with a hammer while the nut is being tightened. After having been finally tightened, nuts shall be locked by upsetting or spoiling the threads as close as possible to the nut face and to a depth of penetration necessary to deform one or more threads on the bolt.

J. High-Strength Bolting:

1. Assemble joints in accordance with AISC RCSC.

2. Tighten bolts to their proof loads with calibrated impact wrenches to a torque not less than recommended for the size of the bolt.

3. Assembly of joints using load-indicator washers shall conform to ASTM F959.

4. Contact surfaces of joints shall be free of paint, lacquer, or other friction-reducing coatings.

K. Sliding Joints: Properly clean sliding-joint assembly bearing surfaces and lubricate as required.

3.02 FIELD QUALITY CONTROL:

A. Field-assembled and installed high-strength bolting shall be inspected and torque-tested in accordance with AISC RCSC by a qualified inspector selected and paid for by the Contractor. Submit the inspector's report of all high-strength bolted connections to the Engineer for review.

3.03 FIELD PAINTING

A. After installation of structural steelwork, abraded areas, field bolts, and welds shall be touched up and spot painted with the same corrosion-inhibitive primer as was used for shop painting in accordance with SSPC-PA 1. Field welds shall be thoroughly wire-brushed or disc-sanded prior to touch-up painting.

B. Steel to receive spray-applied fireproofing shall not be touch-up painted.

C. Steel to receive intumescent fireproofing shall be touch-up painted in accordance with the requirements of the intumescent fireproofing manufacturer.

D. Final field painting of exposed structural steel is specified in Section 09 91 00, Painting.

3.04 GALVANIZING REPAIR

A. Shop galvanized metalwork that become damaged from welding, handling, or installation shall be repaired immediately after installation with galvanizing repair material in accordance with ASTM A780.

END OF SECTION 05 12 00

SECTION 05 21 00

STEEL JOIST FRAMING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Joist and Joist Girders.

B. Anchors and Bolts.

C. Fasteners and Accessories.

D. Grout.

1.02 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for steel joists will be either by the lump-sum method or by the unit-price method as determined by the listing of the bid item for steel joists indicated in the Bid Schedule of the Bid Form.

B. Lump Sum: If the Bid Schedule indicates a lump sum for steel joists, the lump-sum method of measurement and payment will be in accordance with Section 01 20 00, Price and Payment Procedures, Article 1.03.

C. Unit Prices: If the Bid Schedule indicates a unit price for steel joists, the unit-price method of measurement and payment will be as follows:

1. Measurement:

    a. Steel joists will be measured for payment per each joist for each type and size, installed complete in place.

    b. Accessories, bridging, painting, and grouting will not be measured separately for payment; such items will be considered incidental to the steel joist installation.

2. Payment: Steel joists will be paid for at the indicated Contract unit prices for the computed quantities as determined by the measurement method specified in Article 1.02.C.1.

1.03 REFERENCES

A. American National Standards Institute (ANSI)/American Institute of Steel Construction (AISC):

1. ANSI/AISC 360 Specification for Structural Steel Buildings

2. ANSI/AISC 303 Code of Standard Practice for Steel Buildings and Bridges

B. American Society for Testing and Materials (ASTM):

1. ASTM A36/A36M Standard Specification for Carbon Structural Steel
2. ASTM A153/A153M Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
3. ASTM A307 Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod, 60,000 psi Tensile Strength
4. ASTM A449 Standard Specification for Hex Cap Screws, Bolts and Studs, Steel, Heat Treated, 120/105/90 ksi Minimum Tensile Strength, General Use
5. ASTM A563 Standard Specification for Carbon and Alloy Steel Nuts
6. ASTM F436/F436M Standard Specification for Hardened Steel Washers Inch and Metric Dimensions

C. Steel Joist Institute (SJI):

1. Standard Specifications, Load Tables and Weight Tables for Steel Joists and Joist Girders
2. Standard Specifications for Open Web Steel Joists, K-Series
3. Standard Specifications for Longspan Steel Joists, LH-Series and Deep Longspan Steel Joists, DLH-Series
4. Standard Specifications for Joist Girders
5. Technical Digest #8, “Welding of Open Web Steel Joists and Joist Girders”

1.04 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit detailed Shop Drawings of steel joists and joist-girders and related miscellaneous metalwork, showing sizes, details of fabrication and construction, locations of hardware, anchors, and accessories, and erection and installation details.

C. Certification: Submit evidence of SJI membership, or evidence that designs of indicated joists and girders have been checked and accepted by SJI.

D. Inspection Reports: Submit inspection results of required inspections in accordance with the requirements of Article 2.03 herein.

1.05 QUALITY ASSURANCE

A. Fabricators' Qualifications: Fabricator shall be a member of the Steel Joist Institute, or shall be a manufacturer who regularly produces steel joists of the K-, LH-, or DLH-Series, or joist girders conforming to SJI's Specifications and Load Tables and whose designs have been checked and accepted by the Institute.

B. Qualifications of Welders and Welding Procedures: Refer to Section 05 05 22, Metal Welding, for requirements. Comply also with requirements of SJI's Technical Digest #8, "Welding of Open Web Steel Joists and Joist Girders."

PART 2 – PRODUCTS

2.01 MATERIALS AND FABRICATION

A. Joists and Joist Girders: Materials and fabrication (or design and manufacture) of joists shall conform with the referenced SJI Standard Specifications for the type or types of joists and joist girders indicated. Provide horizontal bridging for top and bottom chords as indicated.

1. Joists and girders shall be of the following types as indicated:

    a. Open web steel joists (K-Series);

    b. Longspan steel joists (LH-Series);

    c. Deep longspan steel joists (DLH-Series); and

    d. Joist Girders (G).

B. Accessories:

1. Anchors and Bolts: Bolts and studs, nuts, and washers shall conform with ASTM A307, A449, A563, and F436/F436M, as applicable. Bolts and studs, nuts, and washers shall be hot-dip galvanized in accordance with ASTM A153/A153M.

2. Fasteners and Accessories: Provide anchors and fasteners, washers, straps, and accessories required for a complete and finished installation. Fasteners shall be stainless steel, galvanized steel, or cadmium plated, or other approved non-corrodible metal. Baseplates or bearing plates shall be steel plate conforming to ASTM A36/A36M.

C. Grout: High-Strength, non-shrink grout conforming to requirements of Section 03 61 11, Non-Shrink Grout.

2.02 SHOP PAINTING

A. Steel joists and joist girders shall be properly cleaned and painted in accordance with the referenced SJI Standard Specifications. Conform also with applicable provisions of Section 05 12 00, Structural Steel Framing, for painting of steel for the location.

2.03 INSPECTIONS AND TESTS

A. The Contractor shall require joist manufacturer's inspection as required by the SJI Standard Specifications. Inspection results shall be submitted to the Engineer as specified in Article 1.04 herein.

B. Materials, fabrication, and welds may be inspected by the Engineer in the manufacturer's factory. Inspection method will be visual. The Engineer reserves the right to perform additional inspections and tests on work that is questionable or suspect. Tests will be non-destructive type.

C. The Contractor will bear the cost for the Engineer's inspection and tests, if such inspections and tests reveal failure of portions of the work to comply with requirements indicated in these Specifications. The Contractor shall bear all costs made necessary by such failures including those of repeated testing and inspections.

PART 3 – EXECUTION

3.01 ERECTION

A. Erect steel joists and joist girders as indicated and in accordance with the reviewed and accepted submittals and the SJI Standard Specifications for the type of joists and joist girders indicated. Conform also with applicable requirements of AISC 360 "Specification for Structural Steel Buildings."

B. Align and adjust joists accurately before fastening. Tolerances shall conform with AISC 303 "Code of Standard Practice for Steel Buildings and Bridges." Fastening of splices of compression members shall be performed after the abutting surfaces have been brought into contact. Bearing surfaces and surfaces that will be in permanent contact shall be cleaned before the members are assembled. Splices will be permitted only where indicated.

C. Set joists accurately at the established lines and levels. Joists shall be plumb and level (with indicated allowance for camber) before bolting is commenced. Temporary bracing shall be provided as required and shall be kept in position until completion of erection, anchorage, and bridging.

D. Install support bases, bearing plates, and the ends of top chords, that require grouting, exactly at the proper level by means of steel wedges and by means of adjustment nuts on anchor bolts.

E. Grouting shall conform with the requirements specified in Section 03 61 11, Non-Shrink Grout.

F. Install horizontal bridging for top and bottom chords as indicated and in accordance with the SJI Standard Specifications.

3.02 FIELD PAINTING

A. After erection, spot paint and touch up all field bolts, field welds, and abrasions to the shop coat. Clean surfaces properly as required for paint adherence and as required to prevent corrosion. Use same paint as was used for shop painting.

END OF SECTION 05 21 00

SECTION 05 30 00

METAL DECKING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Floor and Roof Decking.

B. Accessories.

C. Galvanizing Repair Materials.

1.02 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for metal decking will be either by the lump-sum method or by the unit-price method as determined by the listing of the bid item for metal decking indicated in the Bid Schedule of the Bid Form.

B. Lump Sum: If the Bid Schedule indicates a lump sum for metal decking, the lump-sum method of measurement and payment will be in accordance with Section 01 20 00, Price and Payment Procedures, Article 1.03.

C. Unit Price: If the Bid Schedule indicates a unit price for metal decking, the unit-price method of measurement and payment will be as follows:

1. Measurement:

   a. Metal decking will be measured for payment by the square foot or square yard of each type, installed complete in place.

   b. Stud shear connectors, accessories and galvanizing repair will not be measured separately for payment; such items will be considered incidental to the metal decking.

2. Payment: Metal decking will be paid for at the indicated Contract unit prices for the computed quantities as determined by the measurement method specified in Article 1.02.C.1.

1.03 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM A653/A653M — Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

2. ASTM A780/A780M — Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings

B. Steel Deck Institute (SDI):

1. SDI Publication No. 31 Design Manual for Composite Decks, Form Decks, and Roof Decks

2. SDI MOC SDI Manual of Construction with Steel Deck

C. American Iron and Steel Institute (AISI):

1. AISI S100 North American Specification for the Design of Cold-Formed Steel Structural Members

D. American Welding Society (AWS):

1. AWS D1.3/D1.3M Structural Welding Code – Sheet Steel

1.04 REGULATORY REQUIREMENTS:

A. The regulatory requirements which govern the work of this Section include the following governing code:

California Code of Regulations (CCR), Title 24, Part 2, California Building Code, Chapter 22, “Steel”, and Chapter 22A, “Steel”.

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit Shop Drawings that show decking layout, grade, size, section profile, thickness, lengths, openings, lapping, welding, edge closures, flashing, method of attachment, and special support members necessary for a complete installation.

C. Product Data:

1. Submit manufacturer’s catalog sheets including instructions for use and description of application for each type of metal decking. Include ICC report for each type of metal decking for vertical load capacity and diaphragm rating capacity.

2. Submit manufacturer’s product data on galvanizing repair materials.

D. Mill Certificates:

1. Submit mill certificates for each heat of each type of metal decking to be used.

2. Mill certificates shall include name of mill, date of rolling, date of shipping, yield point and minimum tensile strength.

3. Include mill certificates with each lot of material shipped to Jobsite, Contractor certifying that metal decking materials comply with requirements within this Section herein.

4. When mill certificates cannot be provided, the Contractor shall hire a professional testing laboratory to verify compliance and provide laboratory test reports. Provide testing at no cost to District.

E. Laboratory Test Reports:

1. Laboratory test reports shall show the name of testing agency, date of testing, types of tests performed and shall be signed by a principal of the testing agency who is a registered civil or structural engineer in the State of California.

2. Submit laboratory test reports for each deck type tested to show compliance with appropriate ASTM Standards and this section herein.

1.06 QUALITY ASSURANCE

A. Qualifications of Welders and Welding Procedures: Refer to Section 05 05 22, Metal Welding, for requirements.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Decking: Floor and roof decking shall be formed of steel sheet, Grade as indicated, and Coating Designation G90 (1.25 ounce commercial zinc coating) conforming to ASTM A653/A653M. When grade is not indicated, provide minimum Grade B decking. Type of decking units, weight of metal (metal gage), and section profile shall be as indicated.

1. Provide floor and roof decking with prepunched tabs for ceiling suspension hanger wires where indicated or required for suspended ceilings.

B. Accessories: Provide cell end closures, column flashings, recessed sump pans, and any other closures and flashings as indicated or required for complete and finished installations and as required to prevent leakage of concrete. Provide cover caps for covering abutting ends where required. Accessories and flashings shall be of the same material as the decking and shall be not lighter than 22 gage. Accessories shall be the decking manufacturer's standard types, galvanized, and shall be provided as follows:

1. Adjusting plates or segments of deck units in locations too narrow to accommodate full-size units.

2. End closures to close the open ends at openings through the roof, where units terminate at exterior walls, and other locations where required. Closures shall be not lighter than 22 gage.

3. Closures for closing voids above interior walls and partitions that are perpendicular to the direction of the flutes or corrugations. Closures above typical partitions shall be compressible closed cell neoprene or vinyl synthetic rubber. Closures above fire-resistant interior walls and partitions shall be minimum 20 gage sheet steel galvanized, and shall be provided at both sides of the wall or partition.

4. Provide sump pans at drains as indicated, fabricated from metal not lighter than 14 gage.

C. Welding Electrodes: Refer to Section 05 05 22, Metal Welding, for requirements.

D. Stud Shear Connectors: Refer to Section 05 12 00, Structural Steel Framing, for requirements.

E. Galvanizing Repair Materials: Conform with requirements of ASTM A780/A780M. Commercial cold galvanizing compounds manufactured for the purpose will be accepted provided they meet or exceed requirements of ASTM A780/A780M.

2.02 FABRICATION

A. Metal decking and associated metal fabrications shall conform with applicable requirements of the California Building Code, Chapters 22 and 22A, and SDI MOC, and SDI Publication No. 31.

B. Fabricate floor and roof decking for composite construction with shear studs or lugs to provide mechanical key for transferring horizontal shear and for preventing vertical separation. Provide decking with shear studs and hold-down lugs to achieve composite action between decking and concrete fill.

C. Welding and welded connections shall conform with the requirements of Section 05 05 22, Metal Welding.

D. Steel decking and associated fabrications shall be prefabricated and preassembled in the factory or shop as far as practicable.

E. Galvanized metalwork necessitating welding which in any manner removes or damages original galvanizing shall be restored by galvanizing repair in accordance with ASTM A780/A780M.

2.03 INSPECTIONS AND TESTS

A. Materials, fabrications, and welding are subject to inspections in the shop conducted by the Engineer. Tests shall be performed by the Contractor, at Contractor's expense, using an approved independent testing laboratory.

B. Welds shall be inspected by the Contractor as specified in Section 05 05 22, Metal Welding.

PART 3 – EXECUTION

3.01 ERECTION AND INSTALLATION

A. Install decking as indicated and in accordance with the approved submittals, the decking manufacturer's installation instructions, SDI MOC, and SDI Publication No. 31. Provide decking complete, including shaping, cutting, fitting, drilling, welding, flashings, closure strips, closure plates, fasteners, and accessories necessary for a complete and finished installation.

B. Install decking in straight and continuous rows as far as practicable, with ribs at right angles to structural supporting members. End laps shall occur over bearings only, and where sheets are lapped, end laps shall be not less than two inches. Where ends of decking sheets abut without overlapping at supports, each end of decking shall have a minimum bearing of 1-1/2 inches on supports.

C. Stud shear connectors to be installed on metal decking shall be installed directly over webs of beams for single row installations.

D. Type of welding, number of welds, size of welds, and locations of welds shall be in accordance with the approved Shop Drawings and the decking manufacturer's installation instructions. Welding shall conform with the requirements of Section 05 05 22, Metal Welding.

E. Welds shall be cleaned immediately by wire-brushing, and shall be coated with galvanizing repair material before being covered by the succeeding sheet.

F. Decking shall be weighted at the point of welding with sand bags or other approved method to hold them in firm contact with each other and structural supports.

G. Secure solid welds where sheets are warped or bent to certain radii and where decking is placed on a slope while supporting members are framed in a straight position.

H. Button punches or crimping devices may not be substituted for welding.

I. Holes and openings for services and other projections through decking shall be cut and fitted neatly and accurately and shall be reinforced as necessary for rigidity and load-carrying capacity.

J. Welding washers shall be used on deck units with metal thickness less than 0.028 inches.

K. Where welding washers are not used, a minimum visible 5/8 inch diameter arc puddle weld shall be used. Weld metal shall penetrate all layers of deck material at end laps and shall have good fusion to the supporting members.

L. Damaged decking shall be removed and replaced.

M. Metal floor deck holes and openings to be cut after the concrete pour, shall not be field cut until concrete has reached 75 percent of its design strength and a minimum seven days.

3.02 GALVANIZING REPAIR

A. Galvanized surfaces which have become damaged from welding, handling, or installation shall be repaired immediately after installation with galvanizing repair material in accordance with ASTM A780/A780M. Galvanizing repair shall be performed and completed before concrete is placed.

3.03 FIELD QUALITY CONTROL

A. Field welds and shear studs shall be inspected and approved by the Engineer in writing as specified in Section 05 05 22, Metal Welding.

3.04 CONCRETE FILL

A. Concrete fill, where indicated, shall conform with applicable requirements of Section 03 30 00, Cast-in-Place Concrete, and Section 03 05 15, Portland Cement Concrete.

END OF SECTION 05 30 00

SECTION 05 40 00

COLD-FORMED METAL FRAMING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Steel Framing Members.

B. Screws.

C. Bolts.

D. Power-driven Fasteners.

E. Expansion Bolts.

1.02 RELATED SECTIONS

A. Metal framing of 20, 22, and 25 gage metal studs and joists and metal ceiling suspension systems are specified in Section 09 22 00, Supports for Plaster and Gypsum Board.

1.03 MEASUREMENT AND PAYMENT

A. General: Cold-formed metal framing will not be measured separately for payment but will be paid for as part of the indicated Contract lump sum price for Architectural work.

1.04 REFERENCES

A. American Iron and Steel Institute (AISI):

1. AISI D100 — Cold-Formed Steel Design Manual
2. AISI S100 — North American Specification for the Design of Cold-Formed Steel Structural Members

B. American Society for Testing and Materials (ASTM):

1. ASTM A1008/A1008M — Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low Alloy, High-Strength Low Alloy with Improved Formability, Solution Hardened, and Bake Hardenable
2. ASTM A1011/A1011M — Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with improved Formability, and Ultra-High Strength

C. The Society for Protective Coatings (SSPC):

1. SSPC-PA 1 Shop, Field, and Maintenance Painting of Steel

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittals Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit detailed Shop Drawings of steel studs and joists, showing grade, size, and thickness of framing members, layout of framing, installation details, and methods of anchorage and attachment. Indicate strapping, bracing, splices, bridging, and accessories as required for proper installation.

C. Product Data: Submit manufacturer's product data of the framing members, along with applicable accessories.

1.06 DELIVERY AND STORAGE

A. Protect metal framing members from corrosion and damage. Deliver to site in manufacturer's unopened containers or bundles, fully identified by type, size, and grade. Store off the ground in a dry ventilated space.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Steel: Steel for light gage structural framing, studs, tracks, joists, bridging, sills and headers, shall conform with ASTM A1011/A1011M, minimum Grade 33, or ASTM A1008/A1008M, minimum Grade C, with a minimum yield point of 33,000 psi. Light gage structural framing shall conform with applicable requirements of AISI S100 and D100. Framing members and accessories shall be delivered to the job with manufacturer's standard oven-dried coat of corrosion-inhibitive metal primer.

B. Framing Members:

1. Studs: "C" studs or standard channel studs of sizes indicated. Studs shall be 16 gage steel. Short lengths may be 18 gage steel. Studs shall be unpunched where required to be bolted.

2. Tracks: Unpunched channels, of same size, type, and, gage (metal thickness) as studs, for floor and ceiling tracks.

3. Joists: Punched channel joists of sizes indicated. Joists shall be 16 gage steel as indicated. Short lengths may be 18 gage steel. Joists shall be unpunched where required to be bolted. Provide joists for floors, ceilings, and soffits as indicated.

4. Heavier Members: Where studs or joists are required to be heavier steel because of long lengths or heavy loads, provide 12 or 14 gage components as indicated or required.

C. Screws: Self-drilling, self-tapping hardened steel screws manufactured specifically for the purpose and capable of penetrating 12 gage or heavier sheet steel of structural quality. Provide screws with corrosion-inhibitive coating.

D. Bolts: 1/4-inch diameter hot-dip galvanized steel bolts with matching nuts. Provide hot-dip galvanized washers for all bolt heads and nuts.

E. Powder-Driven Fasteners: 1/4-inch diameter fasteners with washers, may be used for attaching tracks in lieu of anchor bolts if first approved by the Engineer for the location. Use washers with all inserts. Powder-driven fasteners will not be permitted for use on concrete curbs or along the edge of concrete or a concrete joint.

F. Expansion Bolts: Hot-dip galvanized expansion type anchors with matching hot-dip galvanized steel bolts or studs with nuts, minimum 1/4-inch diameter, may be used for attaching tracks in lieu of anchor bolts if first approved by the Engineer for the location. Use washers under all bolt heads and nuts. Expansion bolts shall be located at least 4 inches from the edges or corners of concrete.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install steel studs and joists as indicated and in accordance with the approved submittals and the manufacturer's installation instructions by skilled installers experienced in the type of work involved.

B. Provide bridging for studs and joists in accordance with the framing manufacturer's instructions.

C. Install backing plates and reinforcing of the various types indicated or required for the mounting of all items on or in partitions, framed walls, or shafts. Exact position of backing work shall be as designated by the trade whose work will be fastened thereto. The end result shall be that all items attached to or framed in gypsum wallboard surfaces shall be firmly and solidly mounted.

1. Backing plates for grab bars, handrails, and cabinets shall be a minimum of 16 gage galvanized steel, four (4) inches in height, and shall span at least two studs. Backing plates for toilet accessories and other items requiring backing shall be a minimum of 20 gage galvanized steel, four (4) inches in height, and shall span at least one stud past point of connection.

D. Provide miscellaneous steel sections and accessories as indicated or required to complete the work.

E. Erection technique shall result in plumb and straight walls and level ceilings and soffits with no waves or buckles or unevenness at joints. Finished walls shall be a flat plane to within plus or minus 1/8 inch in 8 feet when checked in any direction with an eight-foot straightedge and plumb to within plus or minus 1/8 inch, top to bottom. Finished ceilings shall be level and flat to within plus or minus 1/8 inch in eight (8) feet when checked with a carpenter's level or surveyor's level.

3.02 FIELD PAINTING

A. After erection and installation, spot paint and touch up all field bolts, field welds, and abrasions to the shop coat in accordance with SSPC-PA 1, Shop, Field and Maintenance Painting of Steel. Clean surfaces for paint adherence and as required to prevent corrosion. Provide same paint as was used for shop painting.

END OF SECTION 05 40 00

SECTION 05 50 00

METAL FABRICATIONS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Gratings.

B. Metal Walkways.

C. Trench Drains.

D. Ladders.

E. Concrete Stair Nosing.

F. Steel Clips, Angles, Tubes, Pipes and Shapes.

G. Anchors and Bolts.

H. Galvanizing of Steel and Ferrous Metal Items.

1.02 RELATED SECTIONS

A. Refer to the work under Division 32, Exterior Improvements and Division 33, Utilities, for curb and gutter inlets, catch-basin gratings, manhole covers, and other metalwork associated with, or embedded in, concrete utility structures.

B. Stair nosing for precast concrete steps are specified in Section 03 40 00, Precast Concrete.

1.03 MEASUREMENT AND PAYMENT

A. General

1. Measurement and payment for metal fabrications and miscellaneous metal items will be either by the lump-sum method or by the unit-price method as determined by the listing of the bid item for metal fabrications and miscellaneous metal items indicated in the Bid Schedule of the Bid Form.

2. When metal fabrications or miscellaneous metal items are included as architectural features or components of the structure, they will not be measured separately for payment, but will be included in the lump-sum measurement for Architectural Work.

B. Lump Sum: If the Bid Schedule indicates a lump sum for metal fabrications and miscellaneous metal items, the lump-sum method of measurement and payment will be in accordance with Section 01 20 00, Price and Payment Procedures, Article 1.03.

C. Unit Price: If the Bid Schedule indicates a unit price for metal fabrications and miscellaneous metal items, the unit-price method of measurement and payment will be as follows:

1. Measurement: Metal fabrications and miscellaneous metal items will be measured for payment by the lump sum, by the pound, by the linear or square foot, or per each metal fabrication or miscellaneous metal item, acceptably fabricated and installed, as indicated in the Bid Schedule of the Bid Form. When measured by the pound, weights will be calculated in accordance with AISC Code of Standard Practice for Steel Buildings and Bridges as specified in Section 05 12 00, Structural Steel Framing.

2. Payment:

   a. Metal fabrications and miscellaneous metal items will be paid for at the indicated Contract unit prices for the computed quantities as determined by the measurement methods specified in Article 1.03.C.1.

   b. Metal fabrications and miscellaneous metal items for architectural features or components of the structure will be paid for as part of the indicated Contract lump-sum price for Architectural Work.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM A27/A27M Standard Specification for Steel Castings, Carbon, for General Application
2. ASTM A36/A36M Standard Specification for Carbon Structural Steel
3. ASTM A47/A47M Standard Specification for Ferritic Malleable Iron Castings
4. ASTM A48/A48M Standard Specification for Gray Iron Castings
5. ASTM A53/A53M Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
6. ASTM A108 Standard Specification for Steel Bars, Carbon and Alloy, Cold-Finished
7. ASTM A123/A123M Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
8. ASTM A143/A143M Standard Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement
9. ASTM A153/A153M Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

10. ASTM A307	Standard Specification for Carbon Steel Bolts, Studs and Threaded Rod, 60,000 psi Tensile Strength
11. ASTM A384/A384M	Standard Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies
12. ASTM A385/A385M	Standard Practice for Providing High-Quality Zinc Coatings (Hot-Dip)
13. ASTM A449	Standard Specification for Hex Cap Screws, Bolts and Studs, Steel, Heat Treated, 120/105/90 ksi Minimum Tensile Strength, General Use
14. ASTM A500/A500M	Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
15. ASTM A501/A501M	Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing
16. ASTM A536	Standard Specifications for Ductile Iron Castings
17. ASTM A563	Standard Specification for Carbon and Alloy Steel Nuts
18. ASTM A668/A668M	Standard Specification for Steel Forgings, Carbon and Alloy, for General Industrial Use
19. ASTM A780/A780M	Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
20. ASTM D6386	Standard Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Products and Hardware Surfaces for Painting
21. ASTM F436/F436M	Standard Specification for Hardened Steel Washers Inch and Metric Dimensions
22. ASTM F1554	Standard Specification for Anchor Bolts, Steel, 36, 55, and 105 ksi Yield Strength

B. National Association of Architectural Metal Manufacturers (NAAMM):

1. Metal Bar Grating Manual

C. The Society of Protective Coatings (SSPC):

1. SSPC-SP 1	Solvent Cleaning
2. SSPC-SP 3	Power Tool Cleaning
3. SSPC-PA 1	Shop, Field and Maintenance Painting of Steel

4. SSPC-Paint 20 Zinc-Rich Coating (Type I – Inorganic and Type II – Organic)

5. SSPC-Paint 42 Epoxy Polyamide/Polyamidoamine Primer, Performance-Based

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit fully detailed Shop Drawings of metal fabrications and miscellaneous metalwork, showing sizes, details of fabrication and construction, methods of assembly, locations of hardware, anchors, and accessories, and installation details.

1. Detailing Requirements: Detail steel components as specified in Section 05 12 00, Structural Steel Framing, and items to be galvanized in accordance with applicable requirements of ASTM A384/A384M and ASTM A385/A385M. Detail and fabricate work with suitable drain and vent holes to provide positive drainage and to prevent trapping of moisture and stagnant air.

C. Product Data: Submit manufacturers' product data of all manufactured items and products.

PART 2 – PRODUCTS

2.01 MATERIALS

A. General: Manufactured steel clips and angles will be accepted where such will meet the requirements of the Contract Drawings and are shown on approved Shop Drawings.

B. Steel Materials:

1. Shapes: Standard structural sections, shapes, plates, and bars, as indicated, conforming with ASTM A36/A36M. Bars conforming with ASTM A108 will be accepted.

2. Tubing: Steel tubing, conforming with ASTM A500/A500M or ASTM A501/A501M, of size and shape indicated.

3. Pipe: Steel pipe or round tubing, conforming to ASTM A53/A53M, Type E or S, Grade A, of diameters and sizes indicated. Pipe for sleeves and exterior locations shall be galvanized pipe as specified in ASTM A53/A53M.

C. Welding Rods/Electrodes: Refer to Section 05 05 22, Metal Welding, for requirements.

D. Castings: ASTM A27/A27M, A47/A47M, A48/A48M, or A536, as applicable to the work.

E. Forgings: ASTM A668/A668M, of Class indicated or required.

F. Anchors and Bolts: ASTM A307, F1554, A449, A563, and F436/F436M, as applicable. Bolts and studs, nuts, and washers shall be hot-dip galvanized in accordance with ASTM A153/A153M.

G. Fasteners and Accessories: Furnish anchors and fasteners, washers, straps, and accessories as required for a complete and finished installation. Fasteners shall be stainless steel or hot-dip galvanized steel as appropriate and approved for the location.

H. Concrete and Masonry Anchors: Where anchors are not cast into the concrete or masonry construction, provide hot-dip galvanized expansion type anchors with matching hot-dip galvanized steel bolts or studs with nuts, of sizes as indicated or required. Provide washers under all bolt heads and nuts.

I. Gratings:

1. Bar-Type Gratings:

   a. Provide flat-bar type steel gratings of all-welded construction, consisting of bearing bars and secondary bars in rectangular configuration, with flat/plane level traffic surface, hot-dip galvanized after fabrication. Provide gratings with matching hot-dip galvanized steel frames for anchoring in concrete. Comply with applicable requirements of NAAMM “Metal Bar Grating Manual.”

   b. Notch or frame openings in gratings for penetrations as indicated. Lay out units to allow grating removal without disturbing items penetrating the grating. Provide banding for openings in grating separated by more than four bearing bars, of same material and size as bearing bars.

   c. Cut, drill, and fit gratings as required for installation. Notching of bearing bars to provide supports for maintaining elevations will not be permitted.

2. Perforated Sheet Gratings:

   a. Provide perforated sheet gratings fabricated from button-embossed structural steel sheet of minimum 12 gage thickness, with punched circular holes at apex of buttons for nonslip effect, and punched circular holes between buttons for drainage. Buttons shall be spaced 5/8 inch on centers. Drainage holes shall be spaced 1-1/4 inches on centers, eliminating the buttons at these locations. Hole size for button holes shall be 1/8-inch diameter, plus or minus 1/32 inch. Hole size for drainage holes shall be 1/4-inch diameter, plus or minus 1/16 inch.

   b. Supporting edges shall be channel- or U-shaped, formed edges capable of supporting a uniform live load of 300 pounds per square foot and a concentrated load of 3,000 pounds. Provide additional reinforcing as necessary to support the specified loads.

c. Provide gratings with matching steel frames for anchoring in concrete. Provide frames with appropriate concrete anchors.

d. Gratings and frames shall be hot-dip galvanized after fabrication in accordance with ASTM A123/A123M.

J. Metal Walkways:

1. Provide metal walkways where indicated, fabricated from checkered or diamond-pattern steel plate or from button-embossed structural steel sheet as specified above for perforated sheet gratings.

2. Walkway panels shall be of sizes and plate or sheet thickness indicated, cut or formed to shape and configuration indicated. Walkway panels shall be removable where they serve as covers for wireways and trenches. Provide removable panels/covers with matching steel frames for anchoring in concrete. Provide hinges, chains, and related opening hardware as indicated for wireway covers. All hardware items shall be 300 series stainless steel or hot-dip galvanized after fabrication.

3. Walkway panels shall be capable of supporting a uniform live load of 150 pounds per square foot and a concentrated load of 1,500 pounds.

4. Walkway panels and frames, including supporting and reinforcing components and accessories, shall be hot-dip galvanized after fabrication in accordance with ASTM A123/A123M.

5. When checkered or diamond-pattern steel plate is provided for walkway panels, coat panels with nonslip encapsulated aluminum oxide material bonded or fused to the steel surface. Submit product data and sample for approval.

K. Trench Drains:

1. Provide standard manufactured trench frames with grated or solid covers, as indicated, of sizes and configurations indicated. Trench drains/frames and covers shall be manufactured of gray iron conforming to ASTM A48/A48M or ductile iron conforming to ASTM A536 or a combination of both. Provide heavy-duty type.

2. Provide covers with machined bearing surfaces to prevent rocking and rattling.

3. Where pedestrian traffic will travel over trench drains, provide covers with nonslip surface.

4. That portion of trench drains/frames to be in contact with concrete, earth or fill, shall be coated with bituminous emulsion.

L. Ladders:

1. Provide standard-manufactured or custom-fabricated steel ladders as required to meet the conditions indicated. Steel ladders shall be hot-dip galvanized after fabrication. Ladders may be anodized aluminum where not required to serve as a fire exit.

2. Ship's ladders shall be provided with railings and handrails. Vertical ladders exceeding ten feet in height shall be provided with safety cages.

M. Concrete Stair Nosings: Abrasive cast aluminum in natural metal finish. Provide stair nosings of sizes and profiles indicated with nonslip finish and clean and well-defined cross-hatching and fluting a minimum of 1/16-inch deep. Provide deep lip stair nosings with appropriate integral concrete anchors; holes and countersinks for screw-type anchors are not acceptable. Minimum width of tread surface: 3 inches. Minimum thickness of tread or horizontal portion of nosing: 5/16 inch. Stair nosings for cast-in-place concrete stairs shall have full radius return. Stair nosings for concrete-filled metal pan stairs shall have surface radius. Stair nosings at each tread shall be of a single piece; with no joints.

1. Reflective stripe at stairs:

   a. Furnish and install 2 inch wide 90 mil thick preformed thermoplastic reflective glass bead tape full width of stair nosing.

   b. Color: Yellow. Tape shall be heat adhered to the surface of the cast metal stair tread nosing

2. Stair nosings for precast concrete steps are specified in Section 03 40 00, Precast Concrete.

N. Grout: Provide high-strength, non-shrink grout for base plates and bearing plates in accordance with the requirements of Section 03 61 11, Non-Shrink Grout, and Section 05 12 00, Structural Steel Framing, as applicable.

O. Paint: Corrosion-inhibitive protective metal primer as herein specified under "Cleaning and Painting".

2.02 FABRICATION

A. Metalwork shall be fabricated by firms or shops experienced and skilled in the custom fabrication and construction of metal fabrications and miscellaneous metalwork. There shall be no exposed screws, bolts, and fasteners in the finished work, except as indicated or required.

B. Welded connections shall be made in accordance with requirements of Section 05 05 22, Metal Welding. Welds where exposed to view shall be ground and dressed smooth, so that the shape and profile of the item welded is maintained.

C. Metal fabrications shall be prefabricated and preassembled in the factory or shop as far as practicable.

D. Form and fabricate the work to meet installation conditions. Include anchors, fasteners, and accessories to secure the work in place, as indicated.

E. The Contractor may furnish standard manufactured products for components when applicable, providing such products meet space limitations and installation conditions and are approved by the Engineer.

2.03 GALVANIZING

A. Steel and ferrous metal items on the exterior of buildings, items exposed to the weather and moisture, gratings, and items specifically indicated, shall be galvanized after fabrication by the hot-dip process in accordance with ASTM A123/A123M. Weight of the zinc coating shall conform to the requirements specified under “Weight of Coating” in ASTM A123/A123M. Provide high-quality galvanizing in conformance with ASTM A385/A385M.

1. Seal-weld Overlapping Surfaces: Remove all weld flux. Plug vents provided in seal-welded overlapping surfaces to prevent entry of pickling acids. Remove such plugs before galvanizing.

B. Safeguarding against steel embrittlement shall conform to the applicable requirements of ASTM A143/A143M.

C. Safeguarding against warpage and distortion of steel members shall conform to the applicable requirements of ASTM A384/A384M.

D. Shop galvanized metalwork necessitating field welding which in any manner removes original galvanizing shall be restored by field galvanizing repair in accordance with ASTM A780/A780M.

E. Bolts and screws for attachment of galvanized items shall be galvanized in accordance with ASTM A153/A153M.

2.04 CLEANING AND PAINTING

A. Nongalvanized Metalwork:

1. After fabrication and immediately before shop painting, ferrous metalwork shall be power-tool cleaned in accordance with SSPC-SP 3 to remove mill scale, rust, grease, oil, and any other foreign matter. Welds shall be thoroughly wire brushed.

2. After power-tool cleaning and just before shop painting, ferrous metalwork shall be washed with solvent to remove dust and residue in accordance with SSPC-SP 1.

3. After cleaning and solvent washing, ferrous metalwork shall be shop painted with one coat of corrosion-inhibitive metal primer in accordance with SSPC-PA 1. Materials and application shall conform to SSPC-Paint 20 or SSPC-Paint 42.

B. Galvanized Metalwork:

1. Galvanized metal surfaces indicated to be painted shall be prepared for painting in accordance with ASTM D6386.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install metal fabrications and miscellaneous metalwork as indicated and in accordance with the approved Shop Drawings, using workers skilled and experienced in the installation of the type of work involved.

B. Install metal fabrications and miscellaneous metalwork with all installation accessories furnished by the fabricator as required for complete and finished installations.

C. Installation of metalwork shall be in accordance with approved Shop Drawings, true and horizontal, perpendicular, or at the required angle, as the case may be, level and square, with angles and edges parallel with related lines of the building or structure.

D. Field welding, where indicated, shall conform to requirements of Section 05 05 22, Metal Welding.

E. Where bases and bearing plates require grouting, conform to requirements of Section 03 61 11, Non-Shrink Grout, and Section 05 12 00, Structural Steel Framing, as applicable.

3.02 GALVANIZING REPAIR

A. Galvanized surfaces which have become damaged from welding, handling, or installation shall be repaired immediately after installation with galvanizing repair material in accordance with ASTM A780/A780M.

3.03 FIELD PAINTING

A. After installation, exposed painted surfaces, field welds, and other abraded or damaged primed surfaces shall be prepared as required and touched up with an additional coat of the same primers for ferrous and galvanized surfaces as herein-before specified for shop painting. Spray-paint all touch-up work.

B. Finish field painting, where required, is specified in Section 09 91 00, Painting.

END OF SECTION 05 50 00

SECTION 05 51 00

METAL STAIRS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Concrete Pan-filled Stairs.

B. Industrial Type Stairs.

C. Safety Tread Stairs.

D. Railing System.

1.02 RELATED SECTIONS

A. Railings not directly related to metal stairs are specified in Section 05 52 00, Metal Railings.

B. Stainless steel handrails and railings are specified in Section 05 70 00, Decorative Metal.

C. For stair nosings, see Section 05 50 00, Metal Fabrications.

1.03 MEASUREMENT AND PAYMENT

A. Measurement

1. Metal stairs and related railings and handrails will be measured for payment by the lump-sum method, acceptably fabricated and installed. Top, bottom, and intermediate landings, and supporting steel will be included in the lump-sum measurement.

2. Accessories, shop painting and field touchup, concrete, anchorage and grouting will not be measured separately for payment; such items will be considered incidental to the metal stairs installation.

B. Payment: Metal stairs and related railings and handrails will be paid for at the Contract lump-sum price as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. American Concrete Institute (ACI):

1. ACI 117 Specifications for Tolerances for Concrete Construction and Materials and Commentary

2. ACI 301 Specifications for Structural Concrete

B. American Society for Testing and Materials (ASTM):

1.	ASTM A36/A36M	Standard Specification for Carbon Structural Steel
2.	ASTM A53/A53M	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
3.	ASTM A123/A123M	Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
4.	ASTM A153/A153M	Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
5.	ASTM A307	Standard Specification for Carbon Steel Bolts, Studs and Threaded Rod, 60,000 psi Tensile Strength
6.	ASTM A500/A500M	Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
7.	ASTM A501/A501M	Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing
8.	ASTM A1008/A1008M	Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low Alloy, High-Strength Low Alloy with Improved Formability, Solution Hardened, and Bake Hardenable
9.	ASTM A1011/A1011M	Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with improved Formability, and Ultra-High Strength
10.	ASTM C33/C33M	Standard Specification for Concrete Aggregates

C. The Society for Protective Coatings (SSPC):

1.	SSPC-SP 1	Solvent Cleaning
2.	SSPC-SP 3	Power Tool Cleaning
3.	SSPC-SP 10/NACE No. 2	Near-White Blast Cleaning
4.	SSPC-SP 11	Power Tool Cleaning to Bare Metal

D. United States Access Board:

1. Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities (ADAAG)

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Stair Design: Stairs shall be designed and engineered by the manufacturer, incorporating specified criteria, and employing a professional civil or structural engineer currently registered in the State of California to perform the design engineering. Include design data along with Shop Drawings. Drawings, design data, and calculations shall be stamped and signed by the manufacturer's professional engineer.

C. Shop Drawings: Submit fully detailed Shop Drawings of metal stairs and railings, showing sizes, details of fabrication and construction, methods of assembly, handrail brackets, locations of hardware, anchors, and accessories, and installation details.

D. Product Data: Submit manufacturer's product data of stair type and corrosion-inhibitive finish system. Include patterned or embossed treads, safety coated treads, railing system, handrails, and handrail brackets.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Type and Manufacture: Provide steel stairs of the following types as indicated:

1. Concrete Pan-Filled Stairs: Steel pan-type stairs with concrete-filled treads and landings, and with treads, risers, and platforms constructed of structural steel sheet. Treads shall have nosings.

2. Industrial Type Stairs: Steel stairs with tread fabricated from checkered or diamond-pattern steel plate or sheet, or with treads fabricated from button-embossed structural steel sheet. Risers shall be closed, fabricated from steel sheet.

3. Safety Tread Stairs: Steel stairs with formed steel treads and platforms, coated with anti-skid safety surface, and closed steel sheet risers.

4. Railing System: All stairs shall be provided with a complete stair railing system, including handrails and handrail brackets at walls, fabricated from steel pipe.

B. Stringers and Supporting Steel:

1. Structural Shapes: Standard structural sections, as indicated, conforming to ASTM A36/A36M.

2. Structural Tubing: Welded or seamless steel tubing, conforming to ASTM A500/A500M or ASTM A501/A501M, of size and shape indicated.

C. Treads and Risers, Platforms and Landings:

1. Steel Sheet: Treads, risers, and platforms shall be fabricated from structural steel sheet, of gage or thickness indicated, conforming with ASTM A1011/A1011M or ASTM A1008/A1008M, with minimum yield point of 33,000 psi, formed as indicated. When gage is not indicated, provide 14 gage steel sheet.

2. Patterned Steel Plate: Treads and platforms for industrial-type closed-riser stairs shall be commercial quality checkered or diamond-pattern steel plate or structural steel sheet of thickness indicated, formed to shape and configuration indicated. Risers shall be steel sheet as specified above. Treads and platforms shall be hot-dip galvanized after fabrication in accordance with ASTM A123/A123M.

   a. Button-Embossed Steel Sheet: Treads and platforms may be fabricated from button-embossed structural steel sheet of minimum 12 gage thickness, with punched circular holes at apex of buttons for nonslip effect, and punched circular holes between buttons for drainage. Buttons shall be spaced 5/8 inch on centers. Drainage holes shall be spaced 1-1/4 inches on centers, eliminating the buttons at these locations. Hole size for button holes shall be 1/8-inch diameter, plus or minus 1/32 inch. Hole size for drainage holes shall be 1/4-inch diameter, plus or minus 1/16 inch. Treads and platforms shall be hot-dip galvanized after fabrication in accordance with ASTM A123/A123M.

3. Safety Coated Treads: Formed steel sheet coated with anti-skid or nonslip encapsulated aluminum oxide material bonded or fused to the steel surface. Submit product data and sample for approval.

D. Railings and Handrails:

1. Pipe: Pipe for railings, pipe supports, and handrails shall be seamless steel pipe conforming to ASTM A53/A53M, Type S, Grade A, with special instructions to the manufacturer to provide Architectural Handrail Grade, of diameters and sizes indicated.

2. Handrail Brackets: Provide handrail brackets for handrails at walls, manufactured specifically for the purpose of cast, forged, or wrought steel, of configuration indicated or required to suit conditions, hot-dip galvanized after fabrication.

E. Welding Rod/Electrodes: Refer to Section 05 05 22, Metal Welding, for requirements.

F. Anchors, Fasteners, and Accessories: Provide all required anchors, fasteners, miscellaneous components, and accessories as required for a complete and finished stair installation. Bolts, nuts, and washers shall conform with ASTM A307, galvanized in accordance with ASTM A153/A153M.

1. Expansion Bolts: Where anchors are not cast into the concrete construction, provide hot-dip galvanized expansion type anchors with matching hot-dip galvanized steel bolts or studs with nuts, of sizes as indicated or required. Provide washers under all bolt heads and nuts. Expansion bolts require approval of the Engineer before they may be installed in post-tensioned slabs. Expansion bolts will not be permitted for use on concrete curbs or along the edge of concrete or a concrete joint.

G. Paint: Corrosion-inhibitive protective primer as specified in Article 2.04 herein.

H. Grout: Refer to Section 03 61 11, Non-Shrink Grout, for requirements.

2.02 FABRICATION

A. Metal stairs and railings shall be fabricated by firms or shops experienced and skilled in the construction of metal stairs and architectural railings. There shall be no exposed screws, bolts, and fasteners in the finished work.

B. For items bearing on concrete, provide steel bearing plates and anchors as indicated or required. Base or bearing plates shall be leveled by means of adjustment nuts. The space below plates shall be packed solid with full bed of non-shrink grout. Templates shall be furnished, together with instructions for setting of anchors, anchor bolts, and bearing plates. The Contractor shall supervise and ensure that anchors and related items are properly set in concrete during the progress of the work.

C. Welded connections shall be made in accordance with applicable requirements of Section 05 05 22, Metal Welding. Welding shall be performed in the shop, unless otherwise indicated. Welds where exposed to view shall be ground down and dressed smooth, so that the shape and profile of the item welded are maintained.

D. Holes shall be cut, drilled, or punched at right angles to the surface of the metal and shall not be made or enlarged by burning. Holes in base or bearing plates shall be drilled. Holes shall be provided in members as required to permit connecting the work of other trades.

E. Metal stairs and railings shall be prefabricated and preassembled in the factory or shop as far as practicable.

2.03 GALVANIZING

A. Where certain components are indicated to be galvanized, comply with galvanizing requirements of Section 05 50 00, Metal Fabrications.

2.04 CLEANING AND PAINTING

A. Cleaning and painting shall conform to like requirements specified in Section 05 12 00, Structural Steel Framing.

B. All surfaces of metal stairs and railings, including surfaces of pan-filled stairs, shall be cleaned and treated to assure maximum paint adherence, prior to application of the shop prime coat, in accordance with SSPC-SP 1, SSPC-SP 3, SSPC-SP 10/NACE No. 2, and SSPC-SP 11 as applicable for the exposure and application.

C. Ferrous metalwork shall be given a shop coat of rust-inhibitive metal primer as specified in Section 05 12 00, Structural Steel Framing, or other approved rust-inhibitive metal primer standard with the stair manufacturer. All surfaces of stairwork and railings shall be spray-painted.

D. Where galvanized surfaces are indicated to be painted, comply with cleaning and painting requirements of Section 05 50 00, Meal Fabrications.

E. Coordinate with Section 09 91 00, Painting, for compatibility of the prime coat and finish coats of paint.

2.05 CONCRETE

A. Concrete for pan-filled stair treads and landings shall be concrete, weighing not less than 120 pounds per cubic foot, with a minimum compressive strength at 28 days of 4,000 psi. Maximum aggregate size shall be 3/8 inch (ASTM C33/C33M, Size No. 8). Include a mix of aluminum oxide and silicone carbide grit particles as required to produce non-slip tread surfaces.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Stairs and railings shall be installed by the manufacturer or its authorized representative as indicated and in accordance with the approved Shop Drawings and the manufacturer’s installation instructions. Stairs and railings shall be installed with all accessories furnished by the manufacturer or fabricator as required for complete and finished stair installations.

B. Installation of stair work shall be true and horizontal or perpendicular as the case may be, level and square, with angles and edges parallel with related lines of the building or structure.

C. Shop fabricated items subject to damage shall be braced and carefully handled to prevent distortions or other damage.

D. Field welding, where required, shall conform with requirements specified for shop fabrication.

E. Bearing plates shall be supported at the proper level by means of adjustment nuts on anchor bolts. Bases and plates shall be set accurately using a high-strength, non-shrink grouting mortar to obtain uniform bearing.

3.02 FIELD PAINTING

A. After installation, exposed painted surfaces, field welds, and other abraded or damaged primed surfaces shall be touched up with an additional coat of the same primer for ferrous surfaces as herein before specified for shop painting. Spray paint all touch-up work.

B. Finish field painting is specified in Section 09 91 00, Painting.

3.03 CONCRETE WORK

A. Concrete for pan-filled stairs shall be placed, compacted, finished, and cured in accordance with applicable requirements of ACI 301.

B. Treads and landings shall receive a “troweled finish” in combination with a “nonslip finish” with “very flat” tolerances as specified in ACI 301 and ACI 117.

END OF SECTION 05 51 00

SECTION 05 52 00

METAL RAILINGS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Metal Handrails.

B. Steel Pipe.

C. Steel Plate.

1.02 RELATED SECTIONS

A. Metal handrails and railings related directly to metal stairs are specified in Section 05 51 00, Metal Stairs.

B. Stainless steel handrails and railings are specified in Section 05 70 00, Decorative Metal.

1.03 MEASUREMENT AND PAYMENT

A. Measurement: Metal handrails and railings will be measured for payment by the lump-sum method, acceptably fabricated and installed.

B. Payment: Metal handrails and railings will be paid for at the indicated Contract lump-sum price as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM A36/A36M	Standard Specification for Carbon Structural Steel
2. ASTM A53/A53M	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc Coated, Welded and Seamless
3. ASTM A123/A123M	Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
4. ASTM A143/A143M	Standard Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement
5. ASTM A153/A153M	Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
6. ASTM A307	Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 psi Tensile Strength

7.	ASTM A384/A384M	Standard Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies
8.	ASTM A385/A385M	Standard Practice for Providing High-Quality Zinc Coatings (Hot-Dip)
9.	ASTM A449	Standard Specification for Hex Cap Screws, Bolts and Studs, Steel, Heat Treated, 120/105/90 ksi Minimum Tensile Strength, General Use
10.	ASTM A563	Standard Specification for Carbon and Alloy Steel Nuts
11.	ASTM A780/A780M	Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
12.	ASTM D6386	Standard Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Painting

B. National Association of Architectural Metal Manufacturers (NAAMM):

1.	ANSI/ NAAMM AMP 521	Pipe Railing Systems Manual, Including Round Tube (AMP: Architectural Metal Products)

C. The Society for Protective Coatings (SSPC)/National Association of Corrosion Engineers (NACE):

1.	SSPC-SP 1	Solvent Cleaning
2.	SSPC-SP 3	Power Tool Cleaning
3.	SSPC-SP 10/ NACE No. 2	Near-White Blast Cleaning
4.	SSPC-SP 11	Power Tool Cleaning to Bare Metal

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit detailed Shop Drawings of metal handrails and railings, showing sizes, details of fabrication and construction, bends and radii, handrail brackets, locations of hardware, anchors, and accessories, and installation details.

C. Product Data: Submit manufacturers' product data of railing system and railing components, handrails, and handrail brackets. Include corrosion-inhibitive shop coat painting system.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Metal Handrails: Standard Steel Pipe, Architectural Handrail Grade, of diameter and sizes indicated. Exterior metal handrails shall be hot-dip galvanized. Provide terminal safety returns for all stair handrails. Handrail brackets shall be hot-dip galvanized malleable iron, manufactured for the purpose, for anchorage to concrete walls. Include all fittings and components, sleeves, hardware, backing plates, and accessories as required for complete and finished handrail installations.

B. Steel Pipe: Pipe for railings, pipe supports, and pipe sleeves shall be seamless steel pipe, conforming to ASTM A53/A53M, Type S, Grade A, of diameters and sizes indicated. Special instructions shall be given the pipe manufacturer to provide Architectural Handrail Grade pipe.

C. Plate: Steel plate for anchor plates shall be standard steel plate, conforming to ASTM A36/A36M, weldable quality.

D. Welding Rod/Electrodes: Refer to Section 05 05 22, Metal Welding, for requirements.

E. Anchors, Fasteners, and Accessories: Provide all required anchors, fasteners, miscellaneous components, and accessories as required for complete and finished railing installations. Bolts and studs, nuts, and washers shall conform with ASTM A307, A449, and A563, as applicable, and shall be galvanized in accordance with ASTM A153/A153M.

1. Expansion Bolts: Where anchors are not included in the concrete construction, provide hot-dip galvanized expansion type anchors with matching hot-dip galvanized steel bolts or studs with nuts, of sizes as indicated or required. Provide washers under all bolt heads and nuts. Expansion bolts require approval of the Engineer before they may be installed in post-tensioned slabs. Expansion bolts will not be permitted for use on concrete curbs or along the edge of concrete or a concrete joint.

F. Paint: Corrosion-inhibitive protective metal primer as herein specified under “Cleaning and Painting.”

G. Grout: Refer to Section 03 61 11, Non-Shrink Grout, for requirements.

2.02 FABRICATION

A. Metal handrails and railings shall be fabricated by firms or shops experienced and skilled in the custom fabrication of architectural metal handrails and railings, and shall meet the quality requirements of NAAMM’s Pipe Railing Systems Manual.

B. Bends in rails shall be precision-formed to a smooth continuous radius by skilled workers. Work quality and finish shall be true to detail. Butt joints shall have internal pipe sleeve or dowel. Ends shall be closed with similar materials, welded and ground smooth.

C. Steel welded connections shall be made in accordance with applicable requirements of Section 05 05 22, Metal Welding. Welding shall be performed in the shop unless otherwise indicated. Welded joints of handrails and railings shall be ground and dressed smooth to match adjacent surfaces and so that the shape and profile of the item welded is maintained.

D. Metal handrails and railings shall be prefabricated and preassembled in the factory or shop as far as practicable.

2.03 GALVANIZING

A. Ferrous metal railings and related items on the exterior of the building, or as otherwise indicated, shall be galvanized, after fabrication, by the hot-dip process in accordance with ASTM A123/A123M and ASTM A385/A385M. Weight of zinc coating shall conform with requirements specified under “Weight of Coating” in ASTM A123/A123M.

B. Safeguarding against steel embrittlement shall conform with applicable requirements of ASTM A143/A143M.

C. Safeguarding against warpage and distortion of steel members shall conform with applicable requirements of ASTM A384/A384M.

D. Shop galvanized metalwork necessitating field welding which in any manner removes original galvanizing shall be restored by galvanizing repair in accordance with ASTM A780/A780M.

E. Bolts and screws for attachment of galvanized items shall be galvanized in accordance with ASTM A153/A153M, or of compatible, non-corrodable material.

2.04 CLEANING AND PAINTING

A. Cleaning and painting shall conform to like requirements specified in Section 05 12 00, Structural Steel Fabrication, and Section 05 50 00, Metal Fabrications.

B. All surfaces of metal handrails and railings shall be cleaned and treated to assure maximum paint adherence, prior to application of the shop prime coat, in accordance with SSPC-SP 1, SSPC-SP 3, SSPC-SP 10/NACE No. 2, SSPC-SP 11 as applicable for the type of substrate, exposure, and application.

C. Ferrous metalwork shall be given a shop coat of rust-inhibitive metal primer as specified in Section 05 12 00, Structural Steel Framing, or other approved rust-inhibitive metal primer standard with the railing manufacturer. All surfaces of handrails and railings shall be spray-painted.

D. Where galvanized surfaces are indicated to be painted, comply with cleaning and painting requirements of Section 05 50 00, Metal Fabrications.

E. Coordinate with Section 09 91 00, Painting, for compatibility of the prime coat and finish coats of paint.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install metal handrails and railings as indicated and in accordance with the approved Shop Drawings, using workers skilled and experienced in the installation of the type of work involved. Conform with the installation requirements of NAAMM's Pipe Railing Systems Manual, as applicable.

B. Install metal handrails and railings with accessories furnished by the railing fabricator as required for complete and finished railing installations.

C. Installation of handrails and railings shall be in accordance with approved Shop Drawings, true and horizontal, perpendicular, or at the required angle, as the case may be, level and square, with angles and edges parallel with related lines of the building or structure.

D. Field welding, where required, shall conform with requirements of Section 05 05 22, Metal Welding.

E. Where railing base plates require grouting, conform with requirements of Section 03 61 11, Non-Shrink Grout, and Section 05 12 00, Structural Steel Framing, as applicable.

3.02 GALVANIZING REPAIR

A. Galvanized surfaces which have become damaged from welding, handling, or installation shall be repaired immediately after installation with galvanizing repair material in accordance with ASTM A780/A780M.

3.03 FIELD PAINTING

A. After installation, exposed painted surfaces, field welds, and other abraded or damaged primed surfaces shall be prepared as required and touched up with an additional coat of the same primers for ferrous and galvanized surfaces as hereinbefore specified for shop painting.

B. Lightly sand and feather out such damaged surfaces so that paint touch-up becomes invisible. Spray-paint all touch-up work.

C. Finish field painting is specified in Section 09 91 00, Painting.

END OF SECTION 05 52 00

SECTION 05 70 00

DECORATIVE METAL

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Stainless steel composite panels.

B. Fire hose cabinets.

C. Stainless steel service gates and barriers.

D. Map and schedule cases for transit information display (TID), and advertising frames.

E. Windscreen assemblies.

F. PABX telephone enclosures.

G. Public telephone carrels.

H. Stainless steel handrails and railings.

I. Perforated ceiling panels.

J. Freestanding frames supporting display cases and real-time display monitor.

1.02 RELATED SECTIONS

A. Welding of stainless steel is specified in Section 05 05 22, Metal Welding.

B. Metal handrails and railings related directly to service stairs are specified in Section 05 51 00, Metal Stairs.

C. Painted ferrous and galvanized handrails and railings are specified in Section 05 52 00, Metal Railings.

D. Manufactured stainless steel fire extinguisher cabinets are specified in Section 10 40 00, Safety Specialties.

1.03 MEASUREMENT AND PAYMENT

A. Measurement

1. Decorative metalwork will be measured for payment by the lump-sum method, acceptably fabricated and installed.

2. All items of materials, hardware, fasteners, accessories, incidentals, and their installation will be considered as included in the lump-sum unit measurement.

B. Payment: Decorative metalwork will be paid for at the Contract lump-sum price as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. American National Standards Institute (ANSI):

1. ANSI Z97.1	Glazing Materials Used in Buildings, Safety Performance Specifications and Methods of Test

B. American Society for Testing and Materials (ASTM):

1. ASTM A240/ A240M	Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
2. ASTM A269/ A269M	Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service
3. ASTM A312/ A312M	Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipe
4. ASTM A480/ A480M M	Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
5. ASTM C1048	Standard Specification for Heat Strengthened and Fully Tempered Flat Glass
6. ASTM E84	Standard Test Method for Surface Burning Characteristics of Building Materials
7. ASTM F593	Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs
8. ASTM F594	Standard Specification for Stainless Steel Nuts
9. ASTM F837	Standard Specification for Stainless Steel Socket Head Cap Screws
10. ASTM F879	Standard Specification for Stainless Steel Button and Flat Countersunk Head Cap Screws
11. ASTM F880	Standard Specification for Stainless Steel Socket Square Head, and Slotted Headless Set Screws

C. Code of Federal Regulations:

1. Title 16, Part 1201, Standard of Architectural Glazing Materials (16 CFR 1201)

D. Glass Association of North America (GANA):

1. GANA Glazing Manual

E. National Association of Architectural Metal Manufacturers (NAAMM):

1. NAAMM/ AMP 521 Pipe Railing Systems Manual, Including Round Tube

F. National Fire Protection Association (NFPA):

1. NFPA 101 Life Safety Code

G. Specialty Steel Industry of North America (SSINA):

1. “Designer Handbook” series including the following industry standards:

a. Design Guidelines for the Selection and Use of Stainless Steel, as follows:

1) Specifications for Stainless Steel
2) Special Finishes for Stainless Steel
3) Stainless Steel Fabrication
4) Stainless Steel Fasteners

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit detailed Shop Drawings of decorative metalwork, showing sizes, details of fabrication and construction, handrail brackets, locations of hardware, anchors, and accessories, and installation details.

C. Product Data: Submit manufacturers’ product data of manufactured items and for miscellaneous hardware items associated with decorative metalwork.

D. Samples: Submit samples of stainless steel finishes for the different locations. Pipe and tube shall be submitted in 10-inch lengths; sheet shall be submitted in eight-inch by 10-inch size. Samples shall include joinery and welding.

E. Calculations: Submit structural calculations for freestanding display case frames, including seismic and wind loadings prepared, signed and sealed by a professional engineer currently registered in the State of California. Include structural calculations for each unit’s anchorage to ground, including anchor bolts, footing, and base plate, as applicable. The pipe-to base plate weld shall develop the complete strength of the pipe where connected to the plate (such as properly executed complete joint penetration weld would do).

F. Qualifications: Refer to Article 1.06 entitled “Quality Assurance” for qualification requirements.

G. Mill Test Reports:

1. For freestanding display case frames, submit certified mill test reports of stainless steel materials, covering chemical analysis and physical properties of each heat of steel from which the material for stainless steel will be furnished, in conformance with the hereinafter specified ASTM Specifications. Stainless steel materials shall include base plates, assemblies, posts, pylons, framing connectors and anchors.

1.06 QUALITY ASSURANCE

A. Work Quality:

1. Shop and field work shall be performed by mechanics, craftspersons, artisans, and workers skilled and experienced in the fabrication and installation of the decorative metalwork involved.

2. Decorative metalwork shall be fabricated by firms or shops experienced and skilled in the custom fabrication of architectural decorative metalwork.

3. Stainless steel work shall conform with the quality requirements of the herein referenced Specialty Steel Industry of North America, “Designer Handbook” series standards. Pipe and tube railings shall conform with NAAMM “Pipe Railing Systems Manual, including Round Tube.”

4. Decorative metal components shall match the Engineer’s control samples in quality of fabrication, joinery, welding, and finish.

B. Iron Contamination (Rust): Stainless steel with iron contamination will not be accepted. Dies for forming stainless-steel components shall be stainless steel or chrome-plated to prevent embedment of minute iron particles. All stainless-steel work shall be polished and cleaned after fabrication and installation to prevent rusting susceptibility.

C. Welds of Stainless Steel: Exposed welds shall be ground smooth and polished to match the adjacent surrounding finish of the stainless steel.

D. Regulatory Requirements: Glass and glazing shall comply with applicable requirements of the California Building Code, ANSI Z97.1 and 16 CFR 1201.

E. Manufacturer and Fabricator Qualifications for Freestanding Cases and Frames:

1. Manufacturer and fabricator shall have minimum three years experience in the fabrication of similar stainless steel work to that specified herein for similar projects.

2. Submit a project reference list and photos of public and commercial exterior projects with stainless steel currently in use of similar type and size by the manufacturer.

1.07 KEYS

A. For map and / schedule cases furnish four keys for each station plus an additional six keys.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Handle products and materials in accordance with manufacturer's instructions. Store in a dry and secure location, protected from direct sunlight and excess heat.

PART 2 –PRODUCTS

2.01 MATERIALS

A. Stainless Steel Tube or Pipe: Provide stainless steel tube or pipe, where indicated, conforming to ASTM A269/A269M, Grade TP316, or ASTM A312/A312M, Grade TP316, of diameters and sizes indicated. Provide tube or pipe with a polished finish similar to NAAMM AMP 521 finish. Tube or pipe shall receive a final polishing using grit no coarser than 180 grit. Ends shall be closed with matching material, welded, and ground smooth.

1. Handrails: Provide terminal safety returns for all handrails. Handrail brackets shall be stainless steel, wrought or welded, manufactured for the purpose, for anchorage to indicated substrate. Handrail brackets shall comply with applicable code and loading requirements. Finish of brackets shall match handrail finish. Include all fittings and components, sleeves, hardware, backing plates, and accessories as required for complete and finished handrail installations.

2. Railing Corners: Provide one-quarter sphere components for rounding of 90-degree, outside railing corners. Sphere components shall be welded into position, and the weldments shall be ground and dressed smooth so as to be invisible in the finished work.

B. Stainless Steel Sheet and Plate: ASTM A240/A240M and ASTM A480/A480M, Type 316, of thickness indicated, with ASTM A480/A480M or NAAMM AMP 521 No. 4 polished finish.

C. Anchor Plates: Provide stainless steel anchor plates conforming to ASTM A240/A240M and ASTM A480/A480M , Type 316, with ASTM A480/A480M or NAAMM AMP 521 No. 4 polished finish.

D. Welding Rod/Electrodes: Refer to Section 05 05 22, Metal Welding, for requirements. Provide stainless steel welding electrodes.

E. Anchors, Fasteners, and Accessories: Provide all required anchors, fasteners, miscellaneous components, and accessories as required for complete and finished decorative metal installations. Bolts, studs, and nuts shall conform with ASTM F593, F594, F837, F879, and F880 as applicable, Type 316. Comply also with applicable requirements of SSINA's "Stainless Steel Fasteners." Anchors and fasteners shall be tamper-resistant where exposed.

1. Self-Tapping Screws, Washers and Shims: Oval head, counter-sunk phillips self-tapping screws, washers, and horseshoe shims shall consist of a 316 stainless steel alloy.

2. Expansion Bolts: Where anchors are not included in the concrete or masonry construction, provide stainless steel expansion type anchors with matching stainless steel bolts or studs with nuts, of sizes as indicated or required to meet installation conditions. Provide stainless steel washers under all bolt heads and nuts. Expansion bolts require approval of the Engineer before they may be installed in post-tensioned slabs. Expansion bolts will not be permitted for use on concrete curbs or along the edge of concrete or a concrete joint.

F. Grout: Refer to Section 03 61 11, Non-Shrink Grout, for requirements.

G. Glass: Refer to Section 08 80 00, Glazing, for glass and glazing requirements, including quality assurance provisions for heat-strengthened and tempered glass.

H. Bird Wire System: Refer to Section 10 81 13, Bird Control Devices.

2.02 FABRICATION

A. Form and fabricate the work as indicated and as required to meet installation conditions.

B. Bends in tubes or pipes shall be precision-formed to a smooth continuous radius by skilled workers, true to detail. Butt joints shall have tight-fitting internal pipe sleeve or dowel.

C. Butt joints in stainless steel pipe or tube railings shall not be welded. Instead, railing joints shall have internal, tight-fitting stainless steel sleeve, secured with tamper-resistant, counter-sunk stainless steel fasteners, located at the railing bottom. Butt joints in railings shall be precision-manufactured to provide tight hairline joints, slightly eased at edges to eliminate burrs and sharp edges. Provide for expansion and contraction at joints when railings exceed runs of 40 feet in length.

D. Stainless steel welded connections shall be made in accordance with applicable requirements of Section 05 05 22, Metal Welding. Welding shall be performed in the shop unless otherwise indicated. Welded joints shall be ground and dressed smooth to match adjacent surfaces and so that the shape and profile of the item welded is maintained and so that the weld seam is invisible in the finished work. Welds shall be ground and polished to match NAAMM AMP 521 No. 4 finish.

E. Decorative metalwork shall be prefabricated and preassembled in the factory or shop as far as practicable.

F. All stainless steelwork, after receiving NAAMM AMP 521 No. 4 polished finish, shall receive a final polishing using non-ferrous grit no coarser than 180.

2.03 STAINLESS STEEL COMPOSITE PANELS

A. Materials: Provide stainless steel panels and cladding, as indicated, constructed of composite panels, consisting of stainless steel sheet and backing (balancing) sheet laminated to an inner core. Comply with the following requirements:

1. Stainless Steel Sheet: ASTM A240/A240M and ASTM A480/A480M, Type 316, with ASTM A480/A480M or NAAMM AMP 521 No. 4 polished finish. Construct all face joints flush, continuously welded, ground and polished smooth. Metal gage shall be as indicated. Where metal gage is not indicated, provide minimum thickness of 18 gage.

2. Core: Cement-bonded particle board inner-core panel of thickness indicated. Inner-core panel shall meet the following requirements:

a.	Density	76 pounds per cubic foot
b.	Modulus of Rupture	1300 to 1900 psi
c.	Modulus of Elasticity	725,000 psi
d.	Compressive Strength	2180 psi
e.	Moisture Content	9 percent, plus or minus 3 percent
f.	Surface Burning Characteristics when tested in accordance with ASTM E84	5 flame spread 0 smoke developed 0 fuel contributed
g.	Swelling resulting from water immersion or 24 hours (18mm thick board)	0.86 percent thickness 0.12 percent length 0.07 percent width

3. Backing (Balancing) Sheet: Backing sheet shall be stainless steel of same type, metal gage, and finish of the exposed face sheet. All panels shall be fabricated with backing sheet. Where backing sheet will be concealed in the finished work, the finish may be a nonpolished mill finish.

4. Adhesive: Type I waterproof glue, manufactured for, and capable of, veneering stainless steel and galvanized steel sheet to core material.

B. Assembly: Laminate stainless steel sheets to the inner core material with adhesive applied over full contact area in accordance with adhesive manufacturer's instructions. Apply under pressure. Close all contact edges tight at corner joints, continuously weld, grind, and dress smooth. Refinish and polish all welds to match adjacent No. 4 finish.

C. Cutting of panel edge will not be acceptable.

2.04 FIRE HOSE CABINETS

A. Cabinet Body and Door: Provide cabinet body and door, constructed of a composite panel consisting of stainless steel sheets laminated to an inner core, as follows:

1. Stainless Steel Sheets: ASTM A240/A240M and ASTM A480/A480M, Type 316, with ASTM A480/A480M or NAAMM AMP 521 No. 4 polished finish. Construct all face joints flush, continuously welded, ground and polished smooth. Metal gage as indicated.

2. Core: Cement-bonded particle board inner-core panel as specified in Article 2.03 herein for stainless steel composite panels, of thickness indicated.

3. Assembly: Laminate stainless steel sheets to both sides of the inner-core panel with adhesive applied over full contact area in accordance with adhesive manufacturer's instructions. Close all contact edges tight at corner joints, provide continuous weld, grind, and dress smooth.

4. Angles: Stainless steel, ASTM A240/A240M and ASTM A480/A480M, Type 316, with ASTM A480/A480M or NAAMM AMP 521 No. 4 polished finish where exposed.

5. Gasket: Adhesive applied, weatherproof closed-cell, expanded neoprene gasket, 1/4 inch thick, on cabinet enclosure for sealing door perimeter.

B. Hinges: Stainless steel full length, heavy-duty piano-type, meeting the requirements of ASTM A240/A240M and A480/A480M, Type 316, minimum 14 gage.

C. Latch: Stainless steel and brass, flush type, with spring-loaded catch activated by a pull device. Latch shall be replaceable, vandal-resistant screw mounted.

D. Lock: Cylinder type, CAT 74, compatible with BART's keying system. Comply with Engineer's control sample.

E. Cabinet Identification:

1. Cabinets shall be labeled with the words "FIRE EXTINGUISHER" and "FIRE HOSE" in one-inch high letters, Univers 65 style.

2. Lettering shall be engraved in a separate stainless steel plate that is mounted on the cabinet door. The Letters shall be filled with exterior sign enamel, black as selected by the Engineer.

3. Stainless-steel plate shall have all edges chamfered and shall be secured with tamper-resistant stainless steel fasteners or permanent adhesive.

4. Provide surface mounted clear acrylic plaque with subsurface graphics as indicated in Standard Drawing AS65, Fire Hose Cabinets.

2.05 SERVICE GATES, GUARDRAILS, AND BARRIERS

A. Fabricate top and bottom rails from stainless steel tube or pipe, as indicated, conforming to ASTM A269/A269M, Grade TP316, or ASTM A312/A312M, Grade TP316. Fabricate pickets or balusters from stainless steel square tube or bars, as indicated, Type 316.

B. Neatly cope intersections, fully weld, grind, and polish smooth. Heat curves and blend smoothly without visible distortion of cross section. Provide rounded corners at outside railing corners as herein specified under “Materials.”

C. Gate hinge shall be a floor-mounted, center-hung, double-acting, non-handed closer in a 4-1/16-inch deep steel case with minimum 0.042 inch thick stainless steel cover plate, ASTM A240/A240M and ASTM 480/A480M, Type 316, with ASTM A480/A480M or NAAMM AMP 521 No. 4 finish. Top pivot shall have an oilite bearing for recovering stainless steel pin. Complete assembly shall be handicapped accessible. Comply with Engineer’s control sample.

D. Provide positive stop and latch where indicated. Comply with Engineer’s control sample.

2.06 MAP AND SCHEDULE CASES FOR TRANSIT INFORMATION DISPLAY (TID), AND ADVERTISING FRAMES

A. Frame Units: Fabricate from stainless steel pipe conforming to ASTM A312/A312M, Grade TP316. Form 90 degree elbows by mitering and continuously welding a stainless steel one-quarter sphere to a cut-out area of the pipe as herein specified under “Materials.” Neatly cope intersections, fully weld, and grind smooth and flush so as to be invisible in the finished work.

B. Glazing: Two panes of clear tempered and laminated glass, ASTM C1048, Kind FT, Type I, Class 1, Quality q3, and ANSI Z97.1. Lamination interlayer shall be a minimum of 0.30 inch thick polyvinyl butyral. Size as indicated. Glass shall be set in stainless steel stops with glazing tape consisting of synthetic rubber sheet or strip material reinforced and stabilized with fabric mesh in center and treated with a bonding agent on both contact surfaces. Glazing materials shall conform to applicable requirements of GANA Glazing Manual.

C. Hinge: Stainless steel full length, heavy-duty piano-type, meeting the requirements of ASTM A240/A240M and ASTM A480/A480M, Type 316, minimum 14 gage.

D. Galvanized Sheet Metal: Refer to Section 07 60 00, Flashing and Sheet Metal for material specifications.

1. Bond powder coated galvanized sheet to the interior of stainless steel back plate of case with adhesive.

2. Sheet shall be incorporated in map cases to hold magnets.

E. Locking Mechanism and Keying: Locks shall be keyed compression locks with tubular keys. Combination locks are not acceptable. Locks on a single unit shall be keyed the same. Lock shall include the following features:

1. Size: Small, 1.47 inches, compressed.

2. Lock shall have stainless steel latch body made by metal injection molding, type 316.

3. Lock shall have adjustable grip.

4. Lock shall be suitable for NEMA 4 and IP65 applications.

5. Lock shall include gasket.

6. Lock shall have single turn latching and compression action. Lock shall be snug against gasket in locked position.

F. Anti-graffiti Film: 6 mil protective film: Solar Gard Graffitigard, 3M Anti-Graffiti 4 Window Film, or equal. Film shall be optically clear and removable. Film shall act as a sacrificial barrier to protect glass from paint, key scratches, marking, and acid etching. Film shall be easy to remove and replace when vandalized.

G. Tackless Display Rail: Aluminum tackless paper holder with interlocking roller system adjustable to hold various thickness of paper. Grip-A-Strip as manufactured by Advantus Corporation or equal. Provide manufacturer's-standard mounting brackets. Double sided tape or similar device for mounting is not acceptable.

1. Install grip strip in case to attach and hold top graphic sheets firmly inside the case. Mount rail permanently to the TID case.

2.07 WINDSCREEN ASSEMBLIES

A. Interface and Coordination: Coordinate construction with precast concrete bench details. Refer to Section 03 40 00, Precast Concrete, for requirements.

B. Fabrication: Fabricate from stainless steel pipe conforming to ASTM A312/A312M, Grade TP316. Form 90 degree elbows by mitering and continuously welding a stainless steel one-quarter sphere to a cut-out area of the pipe as herein specified under "Materials." Neatly cope intersections, fully weld, and grind smooth and flush, and polish to match adjacent finish surfaces.

C. Glazing: Provide two panes of tinted tempered and laminated glass, ASTM C1048, Kind FT, Type I, Class 1, Quality q3, and ANSI Z97.1. Lamination interlayer shall be a minimum of 0.30 inch thick polyvinyl butyral. Provide glass of size and thickness indicated. Dry set glass with structural glazing gasket consisting of a single piece neoprene unit that seals with an interlocking neoprene strip after unit grips the glass and frame nib.

D. Precast Concrete Bench Components: Refer to Section 03 40 00, Precast Concrete, for requirements.

E. Stainless Steel Composite Panels: Comply with requirements of Article 2.03 herein.

2.08 PABX PHONE ENCLOSURE

A. Cabinet Body: Stainless steel, ASTM A240/A240M and ASTM A480/A480M, Type 316, with ASTM A480/A480M or NAAMM AMP 521 No. 4 polished finish. Construct all face joints flush, continuously welded, ground and polished smooth. For composite panels, refer to Article 2.03 herein for requirements.

B. Angles: Stainless steel, ASTM A240/A240M and ASTM 480/A480M, Type 316, with ASTM A480/A480M or NAAMM AMP 521 No. 4 polished finish where exposed.

C. Hinges: Stainless steel, full-length, heavy-duty piano-type, meeting requirements of ASTM A240/A240M and ASTM A480/A480M, Type 316, minimum 14 gage.

D. Lock: Cylinder type, CAT 74, compatible with BART’s keying system. Comply with the Engineer’s control sample.

E. Gasket: Apply a weatherproof closed-cell expanded neoprene gasket with adhesive to cabinet enclosure to seal door perimeter.

F. Assembly: Close all contact edges tight at corner joints, continuously weld, grind, and dress smooth.

G. Installation: Pre-drill holes for anchorage.

2.09 PUBLIC TELEPHONE CARREL

A. Fabrication: Fabricate from stainless steel tube or pipe as indicated. Form 90-degree elbows by continuously welding a stainless steel one-quarter sphere to a cut-out area of the pipe as herein specified under “Materials.” Neatly cope intersections, fully weld, and grind smooth and flush.

B. Acoustical Panel: Perforated stainless steel, 16 gage, ASTM A240/A240M and ASTM A480/A480M, Type 316, with ASTM A480/A480M or NAAMM AMP 521 No. 4 polished finish, with sound absorptive black fiberglass ductliner-type backing.

1. Sound-Absorptive Insulation: Panels shall be backed up with ductliner-type insulation board fitted snugly and continuously within the panel’s turned-in or turned-up edges. Insulation board shall conform with the following requirements:

a. Insulation board shall be manufactured from resin-bonded fibrous glass specifically for duct systems with integral vapor barrier. Nominal thickness: one inch. Color: black.

b. Insulation board shall have a flame-spread rating of 25 or less and a smoke-developed contribution of five or less when tested in accordance with ASTM E84, and shall be able to withstand two inches of static pressure.

C. Wiring and Conduits: All wiring and conduits shall be concealed. Exposed wiring and conduits will not be permitted.

2.10 HANDRAILS AND RAILINGS

A. Handrails and Railings: Stainless steel tube or pipe as herein specified under “Materials” and “Fabrication”.

B. Metal Components and Accessories: Stainless steel, Type 316, of configurations and sizes indicated.

C. Handrail Brackets: Provide manufactured 300 Series stainless steel handrail brackets with proper anchorage hardware for adjoining construction.

2.11 PERFORATED CEILING PANELS

A. Stainless Steel Perforated Sheet: No. 16 gage, Type 316 stainless steel with IPA No. 108 pattern perforated sheet, consisting of 5/64-inch diameter holes on 1/8-inch centers, in staggered configuration creating 36 percent open area. Provide and fabricate without border area. Provide with No. 4 polished finish.

B. Fabrication: Fabricate ceiling panels accurately to the sizes and configurations indicated. Provide turned up and returned edges for all panels as indicated. Panels shall be fabricated to be removable. Provide finished holes for fasteners to ceiling framing system.

C. Insulation: Ceiling panels shall be backed up with duct liner-type insulation board fitted snugly and continuously within the panel’s turned up edges. Insulation board shall conform with the following requirements:

1. Insulation board shall be manufactured from resin-bonded fibrous glass specifically for duct systems with integral vapor barrier. Nominal thickness: one inch. Color: black.

2. Insulation board shall have a flame-spread rating of 25 or less and a smoke-developed contribution of five or less, according to NFPA 101, Section 10.2.3.4.1, Class A Interior Wall and Ceiling Finish when tested in accordance with ASTM E84, and shall be able to withstand two inches of static pressure.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install decorative metalwork as indicated and in accordance with the approved Shop Drawings, using workers skilled and experienced in the installation of the type of work involved.

B. Install metal handrails and railings with installation accessories furnished by the railing fabricator as required for complete and finished railing installations.

C. Install decorative metalwork true and horizontal, perpendicular, or at the required angle, as the case may be, level and square, with angles and edges parallel with related lines of the building or structure.

D. Field welding, where required, shall conform with requirements specified herein for shop welding under “Fabrication.” All welds shall be ground and polished smooth to match adjacent finish surfaces.

3.02 CLEANING OF STAINLESS STEEL

A. All stainless steelwork shall be cleaned of all dirt, dust, oil and grease, fingerprints, atmospheric and aqueous corrosion, and iron contamination, rinsed with clear water, and then polished before the Engineer’s final inspection that establishes Substantial Completion of the Contract.

B. The cleaning method shall be the mildest treatment necessary for the problem. For example: a solution of soap, detergent, or ammonia and water, applied with a sponge and rinsed with clear water. If this method is inadequate, then the next stronger method shall be tried, progressively, until satisfactory results are obtained.

C. Heavy dirt, grease, and oil shall be removed with organic solvents or degreasing agents and then thoroughly rinsed with clear water.

D. Corrosion shall be removed by scouring lightly with an abrasive cleaner, rubbing in the direction of the finish grain of the metal. In cases of extreme discoloration, use scouring sponges or steel wool, made only from stainless steel, and then rinsed thoroughly with clean water.

E. Iron contamination shall be removed by passivation, a chemical cleaning method involving the use of nitric acid. This cleaning method shall be performed in the shop only, unless no other treatment at the site is successful. Passivation treatment at the site shall be performed under the continuous supervision of the stainless steel fabricator, employing all required safety precautions and protection of adjacent surfaces.

F. Weldments may require additional fine grinding to remove corrosion or iron contamination if no other cleaning method is successful.

G. All cleaned and rinsed stainless steelwork shall be dried with clean towels and then polished by buffing. If a dull or satin finish is indicated, then buff only enough to remove any remaining residue.

END OF SECTION 05 70 00

SECTION 06 10 00

ROUGH CARPENTRY

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Wood Nailers, Backing and Blocking.

B. Plywood.

C. Anchors and Fasteners.

1.02 RELATED SECTIONS

A. Concrete formwork and falsework are specified in the applicable Sections under Division 3, Concrete.

B. Blocking and backing associated with cabinets and cabinetwork are specified in Section 06 41 00, Architectural Wood Casework.

1.03 MEASUREMENT AND PAYMENT

A. Measurement: Rough carpentry and related rough hardware therefore will not be measured separately for payment.

B. Payment: Rough carpentry and related rough hardware will be paid for as part of the Contract unit price or Contract lump-sum price for the associated work requiring rough carpentry work as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. American Plywood Association (APA):

1. U.S. Product Standard PS-1 Structural Plywood

B. American Society for Testing and Materials (ASTM):

1. ASTM E84 Standard Test Method for Surface Burning Characteristics of Building Materials

C. American Wood Preservers Association (AWPA):

1. AWPA U1 All Timbers Products - Preservative Treatment by Pressure Processes

2. AWPA T1 Use Category System: Processing and Treatment Standard

D. Federal Specifications (FS):

1. TT-W-550 Wood Preservative, Chromated Copper Arsenate Mixture
2. TT-W-571 Wood Preservation: Treating Practices

E. West Coast Lumber Inspection Bureau (WCLIB):

1. Standard No. 17 Grading Rules For West Coast Lumber

F. National Fire Protection Association (NFPA):

1. NFPA 101 Life Safety Code

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, for submittal requirements and procedures.

B. Certification: Provide AWPA grade-stamped pressure-treated wood and plywood as specified herein, or submit certification by the fire-retardant pressure-treating plant that pressure-treated wood and plywood comply with the specified reference standards.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Keep wood products under cover and dry. Protect against exposure to moisture and contact with damp or wet surfaces. Stack material in a manner that promotes air circulation.

PART 2 – PRODUCTS

2.01 WOOD NAILERS, BACKING, AND BLOCKING

A. Wood nailers or nailing strips, backing, and blocking shall be “Construction” or “No. 1” grade Douglas fir as defined in WCLIB No. 17, of size and dimensions indicated or required. Moisture content shall not exceed 19 percent at time of installation.

1. Fire Retardant Treatment: Wood nailers, backing, and blocking shall be pressure-impregnated with an AWPA U1 fire-retardant chemical suitable for the purpose. Each treated member shall be stamped with the AWPA approved trademark and, in addition, the Classification Marking of the Underwriters Laboratories, Inc. for Fire Hazard Classification shall be affixed to the back of each member. Wood nailers and blocking members shall be precut to size and shape before being treated to preclude the need for field cutting and thus exposing untreated surfaces at cut ends. Any members that must still be cut in the field shall be dipped, after cutting, in the same fire-retardant chemical that was used in the pressure treating process.

2. Preservative Treatment: Where wood members are indicated or required to be treated with preservative material, provide pressure-treated “Construction” or “No. 1” grade Douglas fir, treated in accordance with FS TT-W-550 for preservative material (CCA) and FS TT-W-571 or AWPA C1 for pressure treating.

2.02 PLYWOOD

A. Plywood shall be Group 1 Species meeting requirements of U.S. Product Standard PS-1, of sizes and thicknesses indicated or required. Minimum APA Performance Category shall be 5/8. Each panel shall carry the APA grade trademark. Plywood shall be Exterior Grade or manufactured with Exterior Glue, with C-C or C-D (plugged) faces.

1. Fire-Retardant Treatment: Plywood shall be fire-retardant treated in accordance with AWPA C1 to have a flame spread rating of less than 25 (NFPA 101, Section 10.2.3.4.1) when tested in accordance with ASTM E84. Comply also with applicable requirements specified above for wood nailers and blocking.

2.03 ANCHORS AND FASTENERS

A. Wood nailers, backing, and blocking shall be anchored to metal decking with self-drilling, self-tapping, tempered steel screws manufactured for the purpose of securing items to metal decking.

B. Wood and plywood backing and blocking shall be secured to metal framing for gypsum board walls and partitions with self-drilling, self-tapping tempered steel drywall screws of type and size required for the installation.

C. Toggle bolts or screws may be employed to secure wood members to metal framing and substrates through drilled holes, provided the winged anchor is not visible in the finished work.

D. All anchors and fasteners shall be stainless steel, galvanized, or specially treated to prevent corrosion as approved by the Engineer.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install wood nailers, backing, and blocking where indicated and where required for attachment and anchorage of other work.

B. Coordinate location of wood members with other work involved. Provide wood nailers to be embedded in concrete for installation in formwork at the proper time.

C. Attach wood members to substrates as required to support applied loading. Countersink bolt heads and nuts flush with surfaces, unless otherwise indicated.

END OF SECTION 06 10 00

SECTION 06 41 00

ARCHITECTURAL WOOD CASEWORK

PART 1 – GENERAL

1.01 SECTION INCLUDES:

A. Laminated Plastic Work

B. Finish Cabinet Hardware

C. Wood Backing and Blocking

1.02 MEASUREMENT AND PAYMENT

A. Measurement: Custom cabinetwork will be measured for payment by the lump-sum method, acceptably furnished and installed.

B. Payment: Custom cabinetwork will be paid for at the indicated Contract lump-sum price as indicated in the Bid Schedule of the Bid Form.

1.03 REFERENCES

A. American Plywood Association (APA):

1. U.S. Product Standard PS-1 Structural Plywood

B. American Society for Testing and Materials (ASTM):

1. ASTM E84 Standard Test Method for Surface Burning Characteristics of Building Materials

C. American Wood Protection Association (AWPA):

1. AWPA U1 Use Category System

D. National Electrical Manufacturer's Association (NEMA):

1. NEMA LD 3 High-Pressure Decorative Laminates

E. West Coast Lumber Inspection Bureau (WCLIB):

1. WCLIB No. 17 Standard Grading Rules

F. Architectural Woodwork Institute (AWI):

1. Architectural Woodwork Standards

G. Underwriters' Laboratories Inc.

H. National Fire Protection Association (NFPA):

1. NFPA 101 Life Safety Code

1.04 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit fully detailed Shop Drawings of the cabinetwork, including plastic-laminate work and countertop edging. Shop Drawings shall be prepared in accordance with AWI Architectural Woodwork Standards. Shop Drawings shall have an AWI Certified Compliance Label on the first page of drawing set.

C. Product Data: Submit manufacturers' product data for plastic laminates, cabinet hardware, and any other manufactured or fabricated items indicated or specified.

D. Samples: Submit samples of plastic laminates and cabinet finish hardware.

E. Certificates: Submit AWI Certified Compliance Certificate indicating that cabinetwork and its installation meets grade specified.

1.05 QUALITY ASSURANCE

A. Cabinetwork, as indicated, shall be manufactured or fabricated in accordance with the standard details and specifications of AWI Architectural Woodwork Standards, as hereinafter specified.

1.06 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Delivery, storage, and handling of cabinets and related items shall be in accordance with applicable requirements AWI Architectural Woodwork Standards.

PART 2 – PRODUCTS

2.01 WOOD BACKING AND BLOCKING

A. Wood backing and blocking shall be "Construction" or "No. 1" grade Douglas fir as defined in WCLIB No. 17, of size and dimensions indicated or required. Moisture content shall not exceed 19 percent at time of installation.

1. Fire Retardant Treatment: Wood backing and blocking shall be pressure-impregnated with an fire-retardant chemical suitable for the purpose. Each treated member shall be stamped with the AWPA approved trademark and, in addition, the Classification Marking of the Underwriter' Laboratories, Inc. for Fire Hazard Classification shall be affixed to the back of each member. Wood blocking members shall be precut to size and shape before being treated to preclude the need for field cutting and thus exposing untreated surfaces at cut ends. Any members which must still be cut in the field shall be dipped, after cutting, in the same fire-retardant chemical that was used in the pressure treating process.

B. Plywood shall be Group 1 Species meeting requirements of PS 1, of sizes and thicknesses indicated or required. Each panel shall carry the APA grade trademark. Plywood shall be Exterior Grade or manufactured with Exterior Glue, with B-B, B-C or C-C (plugged) faces.

1. Fire-Retardant Treatment: Plywood shall be fire-retardant treated to have a flame spread rating of less than 25, according to NFPA 101, Section 10.2.3.4, when tested in accordance with ASTM E84. Comply also with applicable requirements specified above for wood backing and blocking.

C. Anchors and Fasteners:

1. Wood and plywood backing and blocking shall be secured to metal framing with screws or bolts manufactured for the purpose of type and size required for the installation.

2. Toggle bolts or screws may be employed to secure wood members to metal framing and substrates through drilled holes, providing the winged anchor is not visible in the finished work.

3. All anchors and fasteners shall be stainless steel, galvanized, or specially treated to prevent corrosion.

2.02 CABINET MATERIALS

A. Requirements: Unless specified otherwise herein, cabinetwork materials shall conform with the "Premium" Grade requirements of AWI Architectural Woodwork Standards. All cabinetwork, including shelves and insides of drawers, shall be manufactured with plastic-laminate surfacing. Provide all materials required to complete the work whether herein specified or not, including finish cabinet hardware, specialty items, and accessories. Cabinetry shall accommodate equipment, fixtures, and devices to be provided under other Sections of these Specifications as indicated.

B. Laminated Plastic Work:

1. Surfacing: Plastic-laminate surfacing material, exposed faces and edges, shall be a high-pressure decorative plastic laminate, conforming with NEMA LD 3. Plastic laminate material shall be solid color throughout the thickness of the material, so that when chipped or nicked, there will be no color variation from the surface color. Surface texture and color shall be as selected and approved by the Engineer from manufacturer's standards.

2. Core: The core shall be plywood or medium density fiberboard (MDF). Plywood shall be an approved close-grained hardwood-faced plywood, not less than 5-ply and graded not less than B-B, with both sides sanded. Core shall have no added formaldehyde.

3. Backing Sheet: Backing sheet shall be 0.020 inch standard (balancing) sheet plastic laminate. All laminated plastic work shall be fabricated with backing sheet.

4. Adhesive: Type I waterproof glue manufactured for veneering plastic laminate to core material.

5. Fasteners and Accessories: Provide the required anchors, plates, clips, screws, and accessories for a concealed fastening system and as required for a complete and finished installation.

C. Finish Cabinet Hardware:

1. Requirements:

   a. Provide finish hardware for cabinets as required to complete the Work. Hardware shall be as selected and approved by the Engineer from manufacturers' standards. Cabinet hardware shall conform with the Engineer's control samples.

   b. Furnish all items of finish hardware required to equip the cabinets complete, whether specified herein or not.

   c. Items of hardware not definitely specified herein but necessary for completion of the Work shall be provided at no additional cost to the District. Such items shall be of type and quality suitable for the service required and comparable to adjacent hardware in style and finish.

   d. Each cabinet door shall be provided with appropriate hinges, pull, magnetic catches, elbow catches, and stops. Hinges shall be, at minimum, five-knuckle commercial hinges. Each cabinet drawer shall be provided with pull and drawer slides. Include key-operated locks for all cabinet doors and drawers.

2. Finish: The finish of all hardware shall be US32D, satin stainless, or US26D, satin chrome.

3. Drawer Slides: Drawers shall be fitted with full-extension drawer slides, rated for 100-lb. load capacity minimum.

4. Shelf Standards and Supports: Provide shelf standards and supports of types and sizes indicated or required, conforming the District requirements and with the Engineer's control samples.

5. Door and Drawer Pulls: Provide flush cabinet door and drawer pulls (flush with cabinet face) with finger lip/grip, conforming to the Engineer's control samples.

2.03 FABRICATION

A. Work Quality: The quality of work shall be "Premium" grade flush overlay design in accordance with the requirements for Casework of AWI Architectural Woodwork Standards. Cabinetmakers shall be skilled and experienced, and shall work under competent foremen in the shop and in the field.

B. Laminated Plastic Work: Comply with applicable requirements of NEMA LD 3. Plastic laminate shall be applied to cores with approved waterproof adhesive. Edge laminates shall be applied first. All laminated plastic work shall have backing sheet as herein before specified.

C. Assembly: Cabinetwork shall be assembled as fully as possible in the shop. When field assembly is necessary, the various units shall be accurately prefitted at the shop before shipment.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Installation of cabinetwork shall be as indicated and in accordance with the applicable requirements of AWI Architectural Woodwork Standards for the specified grade. Work quality shall conform to "Premium" Grade requirements, as applicable.

B. Cabinetwork shall be securely anchored and installed as indicated, plumb and level. Use leveling legs or shims where required to level cabinets. Finished work shall be satisfactory in every respect. Provide cut-outs for sinks and equipment, as indicated.

C. Sufficient blocking and backing shall be provided as required to securely anchor all casework and cabinets.

D. Finish hardware shall be installed accurately and securely without marking or defacing hardware or finish work. Test to assure correct alignment and operation. Items of finish hardware shall be fastened at all points where fasteners are indicated or required. Leave all hardware in good working order. Adjust, lubricate, clean, and polish.

END OF SECTION 06 41 00

SECTION 07 01 08

ROOF REPLACEMENT

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Modified Bitumen Roofing.

B. Copper Sheet Roofing.

C. Roof Deck Insulation.

1.02 RELATED SECTIONS

A. Coordinate the work of this Section with the work of other Sections specifying remedial work, corrective measures, and restoration work, including Section 02 41 19, Selective Structure Demolition, and the other Sections of Division 7, Thermal and Moisture Protection as applicable to the work.

1.03 DESCRIPTIONS

A. The Work includes all required related metal flashings, roof drains, metal gutters and downspouts as indicated.

B. The station or building involved in this work will be in continuous operation during the construction period. This will require that the Contractor plan the Work carefully to work around unavoidable obstacles in the prosecution of the Work. It will require further that the Contractor complete some new construction facilities required in the renovation work before proceeding with the re-roofing work.

C. Provide such additional temporary facilities as may be required to facilitate continuous, unobstructed station or building operation during transitional construction work.

1.04 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for re-roofing will be either by the lump-sum method or by the unit-price method as determined by the listing of the bid item for re-roofing indicated in the Bid Schedule of the Bid Form.

B. Lump Sum: If the Bid Schedule indicates a lump sum for re-roofing, the lump-sum method of measurement and payment will be in accordance with Section 01 20 00, Price and Payment Procedures, Article 1.03.

C. Unit Prices: If the Bid Schedule indicates a unit price for reroofing, the unit-price method of measurement and payment will be as follows:

1. Measurement

   a. Reroofing, including removal of existing roofing, restoration of existing roof deck, new roof deck insulation, and new roofing, will be measured for payment by the square foot, as indicated in the Bid Schedule of the Bid Form, acceptably furnished and installed.

   b. Substrate preparation, installation accessories, flashings, related metalwork, protection of non-roofed areas from moisture, and protection of completed surfaces will not be measured separately for payment, but will be considered included with the measurement specified above.

2. Payment: Reroofing, will be paid for at the Contract Unit Price for the computed quantities as determined by the measurement method specified in Article 1.04.C.1.

1.05 REFERENCES

A. Comply with the Reference Standards specified in the other Sections of Division 7 as applicable to the re-roofing work.

1.06 REGULATORY REQUIREMENTS

A. In addition to the foregoing specified referenced standards, the regulatory requirements which govern the work of this Section include the following governing code:

1. California Code of Regulations (CCR), Title 24, Part 2, California Building Code, Appendix Chapter 15, “Roof Assemblies and Rooftop Structures,” and Part 10, California Existing Building Code.

1.07 SUBMITTALS

A. Provide submittals in accordance with the requirements of the other Division 7 Sections as applicable to the reroofing work, for the Engineer’s review.

1.08 QUALITY ASSURANCE

A. Reroofing work shall conform with the installation instructions and recommendations of the manufacturer of the roofing materials to be provided for this work.

B. Quality assurance for the reroofing work shall conform with the quality assurance requirements of the other Division 7 Sections applicable to the work.

1.09 GUARANTY

A. Provide Contractor’s and manufacturer’s guaranty as specified in the Division 7 Sections applicable to the work.

PART 2 – PRODUCTS

2.01 MATERIALS, EQUIPMENT, AND FACILITIES

A. Requirements: Provide all materials, equipment, tools, appurtenances, facilities, and services required for performing and completing reroofing work as indicated.

B. Roofing Materials: Roofing materials shall conform with the applicable Division 7 Sections for the type of roofing indicated, as follows:

1. Roof Deck Insulation: Materials shall conform with the requirements of Section 07 22 00, Roof and Deck Insulation.

2. Modified Bitumen Roofing: Materials shall conform with the requirements of Section 07 52 16, Modified Bitumen Roofing.

3. Copper Sheet Roofing: Materials shall conform with the requirements of Section 07 61 00, Sheet Metal Roofing.

PART 3 – EXECUTION

3.01 EXAMINATION AND PREPARATION

A. After removal of existing roofing, examine all roof deck surfaces for damaged and defective decking. Damaged or defective decking shall be repaired or replaced as required to provide substantial substrate surfaces conducive to the installation of new roof deck insulation and roofing. Substrate surfaces shall be clean and dry before beginning reroofing work.

3.02 ROOF DECK INSULATION

A. Where indicated or required, install roof deck insulation over prepared and clean substrate surfaces in accordance with the requirements of Section 07 22 00, Roof and Deck Insulation.

3.03 INSTALLATION OF NEW ROOFING

A. New roofing shall be installed in accordance with the requirements of the Division 7 Roofing Sections applicable to the work of this Section.

B. All work shall be performed and completed as required to obtain the required guaranty.

END OF SECTION 07 01 08

SECTION 07 12 16

BUILT-UP COAL TAR WATERPROOFING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Concrete Primer.

B. Coal Tar Waterproofing Bitumen.

C. Coal Tar Saturated Felt.

D. Cotton Fabric.

E. Glass Fabric.

F. Flashing Cement.

G. Protective Sheathing Board.

H. Protective Paper.

1.02 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for built-up coal tar membrane waterproofing will be either by the lump-sum method or by the unit-price method as determined by the listing of the bid item for built-up coal tar membrane waterproofing indicated in the Bid Schedule of the Bid Form.

B. Lump Sum: If the Bid Schedule indicates a lump sum for built-up coal tar membrane waterproofing, the lump-sum method of measurement and payment will be in accordance with Section 01 20 00, Price and Payment Procedures, Article 1.02.

C. Unit Prices: If the Bid Schedule indicates a unit price for built-up coal tar membrane waterproofing, the unit-price method of measurement and payment will be as follows:

1. Measurement:

   a. Built-up coal tar membrane waterproofing will be measured for payment by the square yard (square) or square foot complete in place.

   b. No deductions will be made for penetration less than one square yard in area.

   c. Adhesives, fasteners, expansion joints, protection board and paper, and accessories will not be measured separately for payment; such items will be considered incidental to the bituminous membrane waterproofing work and included in the measurement specified above.

2. Payment: Built-up coal tar membrane waterproofing will be paid for at the Contract unit price for the computed quantities as determined by the measurement method specified in Article 1.03.

1.03 REFERENCES

A. American Society for Testing and Materials (ASTM):

1.	ASTM C208	Standard Specification for Cellulosic Fiber Insulating Board
2.	ASTM C981	Standard Guide for Design of Built-Up Bituminous Membrane Waterproofing Systems for Building Decks
3.	ASTM D43/D43M	Standard Specification for Coal Tar Primer Used in Roofing, Dampproofing, and Waterproofing
4.	ASTM D173/D173M	Standard Specification for Bitumen-Saturated Cotton Fabrics Used in Roofing and Waterproofing
5.	ASTM D227/D227M	Standard Specification for Coal-Tar-Saturated Organic Felt Used in Roofing and Waterproofing
6.	ASTM D450/D450M	Standard Specification for Coal-Tar Pitch Used in Roofing, Dampproofing, and Waterproofing
7.	ASTM D1668/D1668M	Standard Specification for Glass Fabrics (Woven and Treated) for Roofing and Waterproofing
8.	ASTM D5643/D5643M	Standard Specification for Coal Tar Roof Cement, Asbestos Free

B. Federal Specifications (FS):

1.	UU-B-790	Building Paper, Vegetable Fiber (Kraft, Waterproofed, Water Repellent and Fire Resistant)

1.04 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Product Data: Submit product data and detailed installation instructions for both vertical and horizontal applications.

C. Manufacturer's Certification: At completion of the installation, submit written certification, signed by the manufacturer or its authorized representative, that the materials used in the work were in accordance with these Specifications, and that they were installed in accordance with the material manufacturer's installation instructions and recommendations.

1.05 QUALITY ASSURANCE

A. Membrane waterproofing system shall be installed by an applicator/installer skilled and experienced in the type of work involved. Applicator shall be licensed and approved by the manufacturer who furnishes the materials.

B. The Contractor shall make necessary arrangements with the manufacturer of the materials to be installed to provide on-site consultation and inspection service to assure the correct installation of the membrane waterproofing.

C. The manufacturer's representative shall be present at the time any phase of the work is performed. Membrane waterproofing shall be applied only over substrate surfaces previously approved by the manufacturer's representative.

1.06 GUARANTY

A. In addition to the guaranty requirements specified in General Conditions Article GC4.9, membrane waterproofing work shall be guaranteed against leakage, defective materials, and defective installation of the completed waterproofing work. Any such defects or leakage occurring during the period of the guaranty shall be promptly and completely corrected, including all affected work, excavation and backfill, at no additional cost to the District.

B. Said guaranty shall be in effect for a period of five years from the date of the Certificate of Substantial Completion issued by the District. The guaranty shall be signed by the waterproofing applicator or installer and countersigned by the Contractor, and shall be submitted to the Engineer as specified in Section 01 77 00, Closeout Procedures.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Concrete Primer: ASTM D43/D43M, creosote primer.

B. Coal-Tar Waterproofing Bitumen: ASTM D450/D450M, Type II, membrane waterproofing type for hot application.

C. Coal-Tar Saturated Felt: ASTM D227/D227M, nominal 15-lb. weight per 108 sq. ft. coal-tar saturated felt.

D. Cotton Fabric: ASTM D173/D173M, bituminous-resin saturated cotton fabric; for use at corners and other sharp bends, and for flashing of penetrations.

E. Glass Fabric: ASTM D1668/D1668M, Type II, woven glass fabric treated with bituminous resin; for bridging of cracks and for the glass-fabric reinforcing ply.

F. Flashing Cement: ASTM D5643/D5643M, coal-tar flashing cement of troweling consistency.

G. Protective Sheathing Board: ASTM C208, vegetable fiber structural insulating board, or other sheathing board acceptable to the Engineer, 1/2 inch thick. For protection of wall waterproofing (vertical surfaces) from backfill damage.

H. Protective Paper: Fed. Spec. UU-B-790, reinforced duplex laminated kraft paper, sealed with heavy-duty cloth masking tape or duct tape. For protection of slab membrane waterproofing (horizontal surfaces) from subsequent construction operations and traffic and from concrete protection slab as applicable.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Inspection of Substrates: Before starting the installation of any waterproofing work, there shall be a preconstruction walk through the areas to receive the waterproofing. Present shall be the Engineer, the Contractor, the installer, and a manufacturer's representative. Together examine all surfaces on which the waterproofing and flashings are to be applied. Examination includes review of transition conditions to ensure a watertight installation.

B. Verify that substrate surfaces are clean and dry, and that concrete is properly aged.

C. Verify that substrate and backing surfaces are smooth and rigid where membrane turns up.

3.02 APPLICATION

A. Apply concrete primer to substrate surfaces at rate recommended by the waterproofing materials manufacturer.

B. Membrane waterproofing for vertical and horizontal surfaces shall be applied in accordance with the latest specifications and installation instructions for membrane waterproofing of the manufacturer who furnishes the materials. One ply of the 4-ply system shall be the glass fabric reinforcing sheet.

C. Comply with the applicable requirements of ASTM C981.

D. Reinforce membrane at inside and outside corners and edges and around penetrations and projections in the substrate. Clamp membrane properly into floor drains.

3.03 FIELD QUALITY CONTROL

A. Verify that kettle temperature of bituminous materials for hot application meets the waterproofing materials manufacturer's recommendations.

B. Verify that installed membrane is free from wrinkles, blisters, exposed laps, fishmouths, and exposed surfaces. Damaged or defective membrane shall be

corrected before covering or concealing the membrane with subsequent construction and finishes.

C. If water test of horizontal surfaces is required by the Contract Specifications, conduct such test by applying a flood coat of water along the high areas so that water at least 1/4-inch deep flows over the areas. Perform test under the observation of the Engineer. Should a leak or low spot appear, repair the area and retest as specified above until all work is watertight and acceptable.

D. Clean adjacent surfaces of spillage and spatterings of bituminous materials.

END OF SECTION 07 12 16

SECTION 07 13 19

MODIFIED BITUMINOUS SHEET WATERPROOFING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Self-adhesive, modified bituminous membrane.

B. Concrete and masonry primer.

C. Flashing cement.

D. Protection board.

E. Temporary protection board for horizontal surfaces.

1.02 RELATED SECTIONS

A. Precast concrete edge slabs at station platform and dielectric insulation for connecting dowels are specified in Section 03 40 00, Precast Concrete.

B. Sealant for dielectric insulation is specified in Section 07 90 00, Joint Protection.

1.03 MEASUREMENT AND PROCEDURES

A. General: Measurement and payment for modified bituminous sheet waterproofing will be either by the lump-sum method or by the unit-price method as determined by the listing of the bid item for modified bituminous sheet waterproofing indicated in the Bid Schedule of the Bid Form.

B. Lump Sum: If the Bid Schedule indicates a lump sum for modified bituminous sheet waterproofing, the lump-sum method of measurement and payment will be in accordance with Section 01 20 00, Price and Payment Procedures, Article 1.02.

C. Unit Prices: If the Bid Schedule indicates a unit price for modified bituminous sheet waterproofing, the unit-price method of measurement and payment will be as follows:

1. Measurement

    a. Modified bituminous sheet waterproofing will be measured for payment by the square yard (square) or square foot complete in place.

    b. Adhesives, fasteners, protection board, and accessories will not be measured separately for payment; such items will be considered incidental to the modified bituminous sheet waterproofing work and included in the measurement specified above.

2. Payment: Modified bituminous sheet waterproofing will be paid for at the Contract unit price for the computed quantities as determined by the measurement method specified in Article 1.03.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM C208	Standard Specification for Cellulosic Fiber Insulating Board
2. ASTM D41/D41M	Standard Specification for Asphalt Primer Used in Roofing, Dampproofing, and Waterproofing
3. ASTM D149	Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
4. ASTM D257	Standard Test Methods for DC Resistance or Conductance of Insulating Materials
5. ASTM D4586/D4586M	Standard Specification for Asphalt Roof Cement, Asbestos-Free

1.05 DESCRIPTION

A. Modified bituminous sheet waterproofing shall be a single-ply, self-adhering, rubberized asphaltic sheet membrane waterproofing system for vertical and horizontal surfaces as herein specified.

1. Membrane waterproofing under station platform slabs and for concourse slabs, where indicated, shall be the modified bituminous sheet waterproofing specified herein only.

B. The work of this Section includes dielectric insulation (membrane waterproofing) of precast concrete edge slabs at the station platform floor slab, as indicated.

1.06 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Product Data: Submit product data and detailed installation instructions for both vertical and horizontal applications

C. Manufacturer’s Certification: At completion of the installation, submit written certification, signed by the manufacturer or its authorized representative, that the materials used in the work were in accordance with these Specifications, and that they were installed in accordance with the material manufacturer’s installation instructions and recommendations.

D. Certified Test Report: Submit evidence of compliance with electrical resistance requirements for applications providing dielectric insulation. Include a certified copy

of test results. Provide such test results as a part of the record documents submittal specified in Section 01 78 39, Project Record Documents.

1.07 QUALITY ASSURANCE

A. Membrane waterproofing system shall be installed by an applicator/installer skilled and experienced in the type of work involved. Applicator shall be licensed and approved by the manufacturer who furnishes the materials.

B. The Contractor shall make necessary arrangements with the manufacturer of the materials to be installed to provide on-site consultation and inspection service at no additional cost to the District, to assure the correct installation of the membrane waterproofing.

C. The manufacturer's representative shall be present at the time any phase of the work is performed. Membrane waterproofing shall be applied only over substrate surfaces previously approved by the manufacturer's representative.

1.08 GUARANTY

A. In addition to the guaranty requirements specified in General Conditions Article GC4.9, membrane waterproofing work shall be guaranteed against leakage, defective materials, and defective installation of the completed waterproofing work. Any such defects or leakage occurring during the period of the guaranty shall be promptly and completely corrected, including all affected work, at no additional cost to the District.

B. Said guaranty shall be in effect for a period of five years from the date of the Certificate of Substantial Completion issued by the District. The guaranty shall be signed by the waterproofing applicator or installer and countersigned by the Contractor, and shall be submitted to the District as specified in Section 01 77 00, Closeout Procedures.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Waterproofing Membrane: Pliable, self-adhesive membrane composed of high-strength polyethylene, factory-coated on one side with a layer of rubberized asphalt in minimum uniform thickness of 0.060 inch. Membrane shall also comply with the following electrical properties:

Property	Test Method	Typical Value
Volume Resistivity, 90 V - 60 sec.	ASTM D257	1.37×10^{14} Ω cm, average of 5 results
Dielectric Breakdown	ASTM D149	500 volts per mil

Property	Test Method	Typical Value
Insulation Resistance	ASTM D257	2.6×10^6 megohm

B. Concrete and Masonry Primer: Asphaltic primer as recommended by the membrane waterproofing materials' manufacturer and conforming generally to ASTM D41/D41M.

C. Flashing Cement: Asphaltic adhesive or mastic as recommended by the membrane waterproofing materials' manufacturer and conforming generally to ASTM D4586/D4586M as appropriate.

D. Protection Board for Vertical Surfaces: Rigid asphaltic-composition board as recommended by the membrane waterproofing materials manufacturer, nominal 1/4-inch thick, or structural insulating board conforming to ASTM C208, applied and held in place with adhesive or sealant recommended by the membrane waterproofing materials' manufacturer.

E. Temporary Protection Board for Horizontal Surfaces: Rigid asphalt-composition, traffic-bearing board, nominal 1/4-inch thick, installed with adhesive recommended by the membrane waterproofing materials' manufacturer.

PART 3 – EXECUTION

3.01 EXAMINATION AND CLEANING OF SUBSTRATE

A. Verify that substrate surfaces are clean and dry, and that concrete is properly aged.

B. Verify that substrate and backing surfaces are smooth and rigid where membrane turns up.

C. Vacuum-clean substrate surfaces as required to remove dirt and dust.

3.02 APPLICATION

A. Apply concrete primer to substrate surfaces at rate recommended by the waterproofing materials manufacturer.

B. Membrane waterproofing for vertical and horizontal surfaces shall be applied in accordance with the manufacturer's latest specifications and installation instructions for membrane waterproofing.

C. Reinforce membrane at inside and outside corners and edges and around penetrations and projections in the substrate. Clamp membrane properly into floor drains.

D. After the membrane waterproofing application on vertical surfaces has been inspected and accepted by the Engineer, install protection board in accordance with the manufacturer's installation instructions and recommendations for protection of the membrane waterproofing from backfilling operations and backfill material. Install temporary protection board with adhesive on horizontal surfaces in accordance with the manufacturer's installation instructions and recommendations for protection from subsequent construction operations and traffic. Protection board damaged during subsequent construction operations and activities shall be immediately repaired or replaced. Remove temporary protection board just before placing concrete topping slabs.

3.03 DIELECTRIC INSULATION

A. In addition to the requirements for membrane waterproofing of horizontal surfaces specified herein, dielectric insulation shall meet the following requirements:

1. Stop membrane waterproofing 1/2 inch below top of finished topping slab to allow for joint sealant application.

2. Seal membrane waterproofing completely around dowel sleeves.

3.04 FIELD QUALITY CONTROL

A. Verify that installed membrane is free from wrinkles, blisters, and exposed surfaces. Damaged or defective membrane shall be corrected.

B. Verify that waterproof membrane is free from defects or damage before covering or concealing the membrane with subsequent construction and finishes.

C. If water test of horizontal surfaces is required by the Contract Specifications, conduct such test by applying a flood coat of water along the high areas so that water at least 1/4 inch deep flows over the areas. Perform test under the observance of the Engineer. Should a leak or low spot appear, repair the area and retest as specified above until all work is watertight and acceptable.

D. Clean adjacent surfaces of spillage and spatterings of bituminous materials.

END OF SECTION 07 13 19

SECTION 07 13 29

BUTYL RUBBER MEMBRANE WATERPROOFING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Butyl rubber sheet membrane.

B. Adhesive.

C. Vulcanizing cement.

D. Butyl gum tape.

E. Membrane protection board.

F. Anti-bonding paper.

G. Rubberized asphalt.

1.02 RELATED SECTIONS

A. Finishing and curing of concrete bridge decks are specified in Section 03 35 00, Concrete Finishing

1.03 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for butyl rubber membrane waterproofing will be either by the lump-sum method or by the unit-price method as determined by the listing of the bid item for butyl rubber membrane waterproofing indicated in the Bid Schedule of the Bid Form.

B. Lump Sum: If the Bid Schedule indicates a lump sum for butyl rubber membrane waterproofing, the lump-sum method of measurement and payment will be in accordance with Section 01 20 00, Price and Payment Procedures, Article 1.02.

C. Unit Prices: If the Bid Schedule indicates a unit price for butyl rubber membrane waterproofing, the unit-price method of measurement and payment will be as follows:

1. Measurement

    a. Butyl rubber membrane waterproofing will be measured for payment by the square yard (square) or square foot complete in place.

    b. Adhesives, tape, expansion joints, protection board, and accessories will not be measured separately for payment; such items will be considered incidental to the membrane waterproofing work and included in the measurement specified above.

2. Payment: Butyl rubber membrane waterproofing will be paid for at the Contract unit price for the computed quantities as determined by the measurement method specified in Article 1.03.

1.04 REFERENCES

A. American Railway Engineering and Maintenance of Way Association (AREMA):

1. Manual for Railway Engineering (herein referred to as the "AREMA Manual"), Volume II, Chapter 8, Part 29, "Waterproofing"

B. American Society for Testing and Materials (ASTM):

1. ASTM D517 Standard Specification for Asphalt Plank

2. ASTM D5329 Standard Test Methods for Sealants and Fillers, Hot-Applied, for Joints and Cracks in Asphalt Pavements and Portland Cement Concrete Pavements

3. ASTM D6690 Standard Specification for Joint and Crack Sealants, Hot-Applied, for Concrete and Asphalt Pavements

C. Federal Specifications (FS):

1. SS-S-1401 Sealants, Joint, Non-Jet-Fuel-Resistant, Hot-Applied, for Portland Cement and Asphalt Concrete Pavements

1.05 DESCRIPTION

A. Membrane waterproofing shall be a single-ply, butyl-rubber sheet membrane waterproofing system for ballasted concrete bridge decks as specified in the AREMA Manual, Chapter 8, Part 29, Part 2, Waterproofing.

1.06 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Product Data: Submit product data and detailed installation instructions for both vertical and horizontal applications.

C. Manufacturer's Certification: At completion of the installation, submit written certification, signed by the manufacturer or its authorized representative, that the materials used in the waterproofing work were in accordance with these Specifications, and that they were installed in accordance with the material manufacturer's installation instructions and recommendations.

1.07 QUALITY ASSURANCE

A. Membrane waterproofing system shall be installed by an applicator/installer skilled and experienced in the type of work involved. Applicator shall be approved by the manufacturer who furnishes the materials.

B. The Contractor shall make necessary arrangements with the manufacturer of the materials to be installed to provide on-site consultation and inspection service to assure the correct installation of the membrane waterproofing.

C. The manufacturer's representative shall be present at the time any phase of the work is performed. Membrane waterproofing shall be applied only over substrate surfaces previously approved by the manufacturer's representative.

1.08 GUARANTY

A. In addition to the guaranty requirements specified in General Conditions Article GC4.9, membrane waterproofing work shall be guaranteed against leakage, defective materials and defective installation of the completed waterproofing work. Any such defects or leakage occurring during the period of the guaranty shall be promptly and completely corrected, including all affected work, at no additional cost to the District.

B. Said guaranty shall be in effect for a period of five years from the date of Certificate of Completion or Substantial Completion issued by the District. The guaranty shall be signed by the waterproofing applicator or installer and countersigned by the Contractor, and shall be submitted to the Engineer as specified in Section 01 77 00, Closeout Procedures.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Waterproofing Membrane: Pliable, butyl-rubber sheet material in minimum uniform thickness of 0.060 inch, conforming to the requirements of the AREMA Manual, Chapter 8, Part 29.

B. Adhesive: As specified in the AREMA Manual, Chapter 8, Part 29.

C. Vulcanizing Cement: As specified in the AREMA Manual, Chapter 8, Part 29, for butyl-rubber membrane splices.

D. Butyl Gum Tape: As specified in the AREMA Manual, Chapter 8, Part 29, for tongue-and-groove splices and lap splices.

E. Membrane Protection: Asphalt plank conforming to ASTM D517, plain type, applied in minimum thickness of one inch using two layers with joints staggered; or asphaltic panels conforming to the AREMA Manual, Chapter 8, Part 29, applied in minimum thickness of 3/4 inch using two layers with joints staggered.

F. Anti-bonding paper shall be a tough, impervious paper with weight of not less than five pounds per 100 square feet.

G. Rubberized Asphalt shall conform to ASTM D6690 or ASTM D5329.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Verify that substrate surfaces are clean and dry, and that concrete is properly aged.

B. Verify that substrate and backing surfaces are smooth and rigid where membrane turns down at edges and vertical surfaces, and up at curbs and other vertical barriers.

3.02 APPLICATION

A. Comply with applicable requirements of the AREMA Manual, Chapter 8, Part 29.

B. Membrane waterproofing shall be applied in accordance with the manufacturer's installation instructions for membrane waterproofing of ballasted bridge decks. Adhesive shall be applied to the entire surface to be waterproofed.

C. All splices and seams of the membrane material shall be tongue and groove butyl membrane splices in accordance with the AREMA Manual, Chapter 8, Part 29.

D. Reinforce membrane at inside and outside corners and edges and around penetrations and projections in the substrate.

E. After the membrane waterproofing application has been inspected and accepted by the Engineer, install protection board with adhesive in accordance with the manufacturer's installation instructions and recommendations, for protection from subsequent construction operations and ballasted track installation. Protection board damaged during subsequent construction operations and activities shall be properly repaired or replaced immediately.

3.03 FIELD QUALITY CONTROL

A. Verify that installed membrane is free from wrinkles, buckles, blisters (trapped air) and other damage. Damaged or defective membrane shall be corrected.

B. Verify that waterproof membrane is free from defects or damage before covering or concealing the membrane with protection board.

C. Clean adjacent surfaces of spillage and spatterings of adhesive materials.

END OF SECTION 07 13 29

SECTION 07 17 00

BENTONITE WATERPROOFING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Bentonite panels.

B. Bentonite tubes.

C. Bentonite gel.

D. Bulk bentonite.

E. Protective cover material.

F. Protection board.

1.02 RELATED SECTIONS

A. Backfill requirements specified in Section 31 00 00, Earthwork.

1.03 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for bentonite waterproofing will be either by the lump-sum method or by the unit-price method as determined by the listing of the bid item for bentonite waterproofing indicated in the Bid Schedule of the Bid Form.

B. Lump Sum: If the Bid Schedule indicates a lump sum for bentonite waterproofing, the lump-sum method of measurement and payment will be in accordance with Section 01 20 00, Price and Payment Procedures, Article 1.02.

C. Unit Prices: If the Bid Schedule indicates a unit price for bentonite waterproofing, the unit-price method of measurement and payment will be as follows:

1. Measurement

    a. Bentonite waterproofing will be measured for payment by the square yard or square foot complete in place. Double-layer installation will be measured separately from single-layer installation; however, overlaps in a single layer will not be measured.

    b. Tubes, gel, bulk bentonite, protective cover sheet, protection board, fasteners, and miscellaneous accessories will not be measured separately for payment; such items will be considered incidental to the bentonite waterproofing work and included in the measurement specified above.

2. Payment: Bentonite waterproofing will be paid for at the Contract unit price for the computed quantities as determined by the measurement methods specified in Article 1.03.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM D7832/D7832M Standard Guide for Performance Attributes of Waterproofing Membranes Applied to Below-Grade Walls/Vertical Surfaces (Enclosing Interior Spaces)

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Product Data: Submit manufacturer's product data demonstrating compliance with specification requirements. Submit manufacturer's installation instructions and details, separately for each condition of bentonite waterproofing installation.

1.06 QUALITY ASSURANCE

A. Bentonite waterproofing system shall be installed by an applicator/installer skilled and experienced in the type of work involved. Applicator shall be licensed and approved by the manufacturer who furnishes the materials.

B. The Contractor shall make necessary arrangements with the manufacturer of the bentonite materials to be installed to provide on-site consultation and inspection service to assure the correct installation of the bentonite waterproofing.

C. The manufacturer's representative shall be present at the time any phase of the work is performed. Bentonite waterproofing shall be installed only over substrate surfaces previously approved by the manufacturer's representative.

1.07 DELIVERY, STORAGE AND HANDLING

A. Store bentonite materials in a dry location, off the ground, and protected from physical damage and moisture.

1.08 ENVIRONMENTAL CONDITIONS

A. Do not install bentonite products in standing or running water conditions, or during rain or damp weather.

1.09 GUARANTY

A. In addition to the guaranty requirements specified in General Conditions Article GC4.9, bentonite waterproofing work shall be guaranteed against leakage, defective materials, and defective installation of the completed waterproofing work. Any such defects or leakage occurring during the period of the guaranty shall be promptly and completely corrected, including all affected work, at no additional cost to the District.

B. Said guaranty shall be in effect for a period of five years from the date of the Certificate of Substantial Completion issued by the District. The guaranty shall be signed by the bentonite waterproofing applicator or installer and countersigned by the Contractor, and shall be submitted to the Engineer as specified in Section 01 77 00, Closeout Procedures.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Requirements: Bentonite waterproofing system shall include bentonite panels, bentonite in tube, gel, or mastic form, and dry granular bentonite, all products of a single manufacturer.

B. Bentonite: Specially selected natural Wyoming type granular bentonite, containing a minimum 90 percent montmorillonite, graded so that 90 percent will pass a 20 mesh sieve and less than 10 percent will pass a 200 mesh sieve.

C. Panels: Minimum one pound granular bentonite per square foot, packed into flutes of corrugated biodegradable kraft board or between layers of porous polypropylene.

D. Tubes: Granular bentonite in two-inch diameter water soluble tubes.

E. Gel: Trowelable grade of bentonite that has been hydrated to maximum gel strength.

F. Bulk Bentonite: Dry granular bentonite packaged in 50-pound bags.

G. Protective Cover Sheet: Minimum four mil thick polyethylene.

H. Protection Board: As recommended by the bentonite products' manufacturer.

PART 3 – EXECUTION

3.01 GENERAL INSTALLATION REQUIREMENTS

A. Protect bentonite from premature hydration at all times. Where bentonite is installed directly against earth or wood lagging, place a layer of protective cover sheet under the bentonite. Where backfill or concrete is not placed against bentonite immediately after the bentonite is installed, cover the bentonite with protective cover sheet until backfill is placed. As an alternative to the foregoing, bentonite panels that have been coated with a water-repellent resin on the exposed face may be used.

B. When the presence of salt in the groundwater is indicated, use only bentonite that is certified by the manufacturer for use under salt water conditions without freshwater pre-hydration. Obtain groundwater samples and have them tested by the manufacturer if necessary to obtain this certification.

C. Apply two or more layers of bentonite panels wherever the indicated hydrostatic head exceeds the manufacturer's rated depth for single-layer installation. Comply with the manufacturer's special requirements for installation at such depths. When installing double layers, do not overlap joints; butt panels together and stagger joints in the two layers a minimum of 12 inches.

3.02 INSTALLATION ON FREE-STANDING WALLS

A. Preparation:

1. Concrete surfaces shall be free of large voids and projections (such as mortar fins) extending more than 1/16 inch from the surface. Grind off such projections. Fill voids with cement mortar or bentonite gel.

2. On concrete block masonry surfaces, apply a 1/2 inch thick parge coat of sand-cement and allow to cure three days before applying bentonite.

3. Do not commence installation until preparation is complete and has been inspected and approved by the manufacturer's representative.

B. Attach panels with 3/4 inch or one inch masonry washer-head nails. Lap adjoining panels a minimum of 1-1/2 inches. Stagger vertical joints in succeeding courses.

C. When cutting, trimming, and folding, follow manufacturer's instructions to prevent loss of bentonite granules.

D. Cut panels to fit around pipes and penetrations. Trowel a fillet of gel around the penetration and a minimum of two inches up the penetration just prior to backfilling.

E. Provide protection board when the backfill contains sharp stones (such as crushed rock) or any stones larger than two inches.

F. Refer to Section 31 00 00, Earthwork, and Article 3.01.A above regarding backfill requirements. Exercise care to avoid damage to bentonite waterproofing by backfilling operations.

3.03 INSTALLATION UNDER SLABS AND FOOTINGS

A. Place a layer of protection sheet over the substrate to prevent premature hydration of bentonite, or use panels having a water-resistant coating.

B. Overlap panels a minimum of 1-1/2 inches and nail into soil or staple together. Stagger joints in succeeding courses.

C. Where slabs are poured in sections, necessitating the use of side forms with stakes, install panels to extend a minimum of six inches beyond the outside of the form. Drive the form stakes through the extended panels. When the stakes are removed, fill the holes with dry bentonite granules, and overlap the stake holes with the next panel. Do not allow polyethylene sheeting, where used, to extend between overlapped panels.

D. Do not extend panels over pile caps or piles, except as specifically indicated.

E. Comply with manufacturer's instructions for extension of panels up the outer sides of slabs and footings.

3.04 INSTALLATION AGAINST SIDES OF SUPPORTIVE EXCAVATION

A. When bentonite panels are installed directly against the inside surface of soldier piles and lagging, diaphragm walls, or other support system to be left in place, prepare the surface by filling voids greater than 1/2 inch with cement mortar, or place a suitable geotextile over the entire surface.

B. If water is present on the surface of the excavation support, place protective cover sheet over the surface or use panels having a water-resistant coating.

C. Overlap panels a minimum of 1-1/2 inches and nail in place. Stagger joints in succeeding layers. Do not extend panels beyond finish grade.

3.05 FIELD QUALITY CONTROL

A. Verify that bentonite waterproofing is free from defects or damage before backfilling or concealing the waterproofing with subsequent construction and finishes. Damaged or defective waterproofing shall be corrected.

END OF SECTION 07 17 00

SECTION 07 18 16

VEHICULAR TRAFFIC COATINGS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Liquid-applied elastomeric, vehicular traffic-bearing, waterproofing.

B. Flashings.

C. Traffic surface.

1.02 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for vehicular traffic deck coating will be either by the lump-sum method or by the unit-price method as determined by the listing of the bid item for vehicular traffic deck coating indicated in the Bid Schedule of the Bid Form.

B. Lump Sum: If the Bid Schedule indicates a lump sum for vehicular traffic deck coating, the lump-sum method of measurement and payment will be in accordance with Section 01 20 00, Price and Payment Procedures, Article 1.03.

C. Unit Prices: If the Bid Schedule indicates a unit price for vehicular traffic deck coating, the unit-price method of measurement and payment will be as follows:

1. Measurement

    a. Vehicular traffic deck coating, will be measured for payment by the square foot or square yard, as indicated in the Bid Schedule of the Bid Form, acceptably furnished and installed.

    b. Substrate preparation, installation accessories, and protection of completed surfaces will not be measured separately for payment, but will be considered included with the measurement specified above.

2. Payment: Vehicular traffic deck coating, will be paid for at the Contract unit price for the computed quantities as determined by the measurement method specified in Article 1.02.C.1.

1.03 SYSTEM DESCRIPTION

A. The traffic deck coating (traffic topping) system shall be a VOC-compliant, cold, liquid-applied polyurethane or aliphatic urethane, elastomeric, waterproof membrane with integral skid-resistant vehicular traffic-bearing wearing surface.

B. The membrane may be single-component or multi-component, and shall consist of at least three coats (base, intermediate, and top coats), built up to a minimum overall dry-film thickness of 45 mils or the minimum thickness recommended by the manufacturer's installation instructions, whichever is greater. The finished installation shall be capable of bridging 1/16 inch new cracks and floor movement, at a minimum, without failure. Membrane shall be recoatable and repairable.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM C957/C957M Standard Specification for High-Solids Content, Cold Liquid-Applied Elastomeric Waterproofing Membrane with Integral Wearing Surface
2. ASTM C1486 Standard Practice for Testing Chemical-Resistant Broadcast and Slurry-Broadcast Resin Monolithic Floor Surfacings
3. ASTM D4263 Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method

B. International Concrete Repair Institute (ICRI):

1. ICRI Technical Guideline No. 310.2R Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit installation and flashing details for all roof deck penetrations, curbs, and parapets.

C. Product Data: Submit manufacturer's product data and installation specifications of the traffic deck coating system.

D. Samples: Submit sample 10-inch squares of the finished traffic deck coating installation, in manufacturer's standard color as selected by the Engineer. Color and texture proposed for the finished installation require approval of the Engineer before the work of this Section may proceed.

E. Manufacturer's Certification: At completion of the installation, submit written certification, signed by the manufacturer or its authorized representative, that the materials used in the work were in accordance with these Specifications, and that they were installed in accordance with the material manufacturer's installation instructions and recommendations.

1.06 QUALITY ASSURANCE

A. Vehicular traffic-bearing deck coating system shall be installed by an applicator/installer skilled and experienced in the type of work involved. Applicator/installer shall be licensed and approved by the manufacturer that furnishes the materials.

B. The Contractor shall make necessary arrangements with the manufacturer of the materials to be installed to provide on-site consultation and inspection services to assure the correct installation of the traffic-bearing deck coating system.

C. The manufacturer's representative shall be present at the time any phase of the work is started. Membrane waterproofing deck coating system shall be applied only over substrate surfaces previously approved by the manufacturer's representative.

1.07 GUARANTY

A. Waterproof traffic-bearing deck coating work shall be guaranteed against defective materials and work quality and against leakage due to faulty or inferior materials, inadequate installation, and installation supervision, and inadequate protection of completed work. Any such defects or leakage occurring during the period of the guaranty shall be promptly and completely corrected, including all affected work, at no additional cost to the District.

B. In addition to the guaranty requirements specified in General Conditions Article GC4.9, said guaranty shall be in effect for a period of five years from the date of the Certificate of Substantial Completion issued by the District. The guaranty shall be signed by the deck coating system applicator or installer and countersigned by the Contractor, and shall be submitted to the Engineer as specified in Section 01 77 00, Closeout Procedures.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Deck Type and Manufacturer: The liquid-applied polyurethane or aliphatic urethane elastomeric, waterproof, traffic-bearing floor and base coating system and materials shall conform to applicable requirements of ASTM C957/C957M, and shall be the products of a manufacturer who specializes in and is regularly engaged in the manufacture of these materials. Latex type membrane coating systems will not be acceptable. Include the base coat, intermediate coats, and top coat, and all installation accessories and non-skid materials, all by the same manufacturer.

B. Flashings: Flashings shall be an integral composition flashing material similar to and monolithic with the elastomeric membrane specified above.

C. Color: Color of the traffic surface and base shall be as selected and approved by the Engineer from manufacturer's standard colors.

PART 3 – EXECUTION

3.01 INSPECTION AND PREPARATION OF SUBSURFACES

A. Inspection of Subsurfaces: Before starting the installation of any traffic-bearing deck coating work, examine all surfaces that the deck coating and base membrane and flashings are to be applied. Examination includes bond, moisture, and alkali testing of concrete as required or recommended by the manufacturer of the deck coating system components.

1. Test concrete deck for moisture in accordance with ASTM D4263.

B. Cleaning and Preparation of Substrate Surfaces:

1. Substrate surfaces that the deck coating membrane, base, and flashings are to be applied shall be dry; clean of dirt, dust, paint, and grease; and free of bond-breaking and curing compounds.

    a. Concrete substrate surfaces shall be properly prepared and cleaned in accordance with ASTM C1486 as recommended by the deck coating system manufacturer.

    b. Where the manufacturer determines that the concrete substrate needs to have a "roughened" surface to provide mechanical key for better adhesion of the base coat, perform shotblasting or bead blasting in accordance with ICRI Technical Guideline No. 310.2R.

2. Substrate surfaces shall be free from roughness and defective surfaces that prevent a level and plane installation. Fill joints, cracks, and depressions in substrate surfaces with floor patch or underlayment material recommended by the manufacturer of the deck coating system components, as required. Substrate surfaces shall be level to within 1/8 inch in eight feet when checked in any direction by an eight-foot straightedge, or sloped for drainage as indicated.

3.02 INSTALLATION

A. The waterproof, composition, elastomeric traffic-bearing membrane coating system and related flashings shall be installed in accordance with the manufacturer's specifications, installation instructions, and recommendations, using only workers skilled and experienced in the installation of the type of work involved.

B. The finished installation shall be uniform in color and texture.

3.03 FIELD QUALITY CONTROL

A. Verify that the installed deck coating membrane is free from wrinkles, blisters, and exposed surfaces. Damaged or defective membrane shall be corrected.

B. If water test of horizontal surfaces is required by the Contract Specifications, conduct such test by applying a flood coat of water along the high areas so that water at least 1/4 inch deep flows over the areas. Perform test under the observation of the Engineer. Should a leak or low spot appear, repair the area and retest as specified above until all work is watertight and acceptable.

C. Clean adjacent surfaces of spillage and spatterings of deck coating materials, if any.

END OF SECTION 07 18 16

SECTION 07 21 11

BUILDING INSULATION

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. This Section includes specifications for thermal insulation for roof attic spaces and exterior walls of station structures and other buildings as indicated.

B. This Section also includes acoustical (sound-retardant) insulation for interior walls and partitions, furred spaces, and ceilings as indicated.

1.02 MEASUREMENT AND PAYMENT

A. General: Building insulation will not be measured separately for payment but will be paid for as part of the Contract lump sum price for Architectural Work.

1.03 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM C553 Specification for Mineral Fiber Blanket and Thermal Insulation for Commercial and Industrial Applications
2. ASTM C665 Specification for Mineral Fiber Blanket Thermal Insulation for Light Frame Construction and Manufactured Housing
3. ASTM E84 Test Method for Surface Burning Characteristics of Building Materials

PART 2 – PRODUCTS

2.01 MATERIALS

A. Fire-Retardant Requirements: Insulation shall have a flame-spread rating of 25 or less and a smoke-developed index of 50 or less when tested in accordance with ASTM E84.

B. Thermal Insulation: Fiberglass or mineral-fiber foil-faced standard building insulation with vapor barrier and flanges for fastening, meeting requirements of ASTM C553 or ASTM C665, as applicable, minimum thermal resistance, R value of 19 with minimum nominal installed thickness of six inches for attic spaces (underside of roof decks), and minimum thermal resistance, R value of 11 with minimum nominal installed thickness of three inches for exterior walls.

C. Acoustical Insulation: Fiberglass or mineral-fiber foil-faced or unfaced sound-attenuation batts or blankets for tight friction fit between framing members, meeting

requirements of ASTM C553 or ASTM C665, as applicable. Provide minimum three-inch thick batts or blankets for furred spaces, stud walls, and spaces above suspended ceilings. Insulation shall provide a minimum sound transmission class (STC) assembly rating of 50 (45 if field tested) when installed in standard 3-5/8-inch steel-stud wall with single layers of 5/8-inch gypsum board both sides.

D. Fasteners and Adhesives: Provide fastening or attaching devices, nails, staples, stick clips, and adhesives as required to securely fasten or hold insulation in place, as recommended by the manufacturer of the insulation used.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Insulation shall be installed in all locations as indicated. Insulation shall be installed in accordance with the manufacturer's installation instructions and recommendations, using fasteners and adhesives as required. In attic spaces and exterior walls, insulation shall be installed with the foil face facing the interior of the building.

B. Insulation shall be installed to the underside of metal roofing in attic spaces with stick clips and adhesive as required to provide a blanket membrane without sags. If sagging occurs, provide No. 10 or No. 12 wire, tautly installed, to help hold insulation in place and to keep insulation from sagging.

C. Batt or blanket type insulation shall be installed between studs and joists, fitted between (not over) plates, braces, blocking, or solid bridging, with no voids of insulation.

D. Acoustical insulation shall be installed tightly between studs, joists, plates, braces, and blocking, with no voids of insulation. Provide adhesive, tape, or other appropriate fasteners where required to hold insulation rigidly in place. Openings and penetrations in acoustical walls and partitions shall be sealed airtight.

E. Provide minimum three-inch thick batt or blanket insulation in wall cavities containing plumbing and heating pipes. Include ceiling cavities within 12 inches of plumbing and heating pipes.

F. Insulation shall be installed after piping and wiring have been installed, tested, inspected, and approved.

END OF SECTION 07 21 11

SECTION 07 22 00

ROOF AND DECK INSULATION

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Roof insulation.

B. Adhesive.

C. Fasteners.

D. Roof tape.

E. Asphalt.

F. Bituminous plastic cement.

G. Wood stops, blocking, and insulation-containment members.

1.02 MEASUREMENT AND PAYMENT:

A. Roof deck insulation will not be measured separately for payment but will be paid for as part of the Contract lump sum price for Architectural Work.

1.03 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM C726 Specification for Mineral Fiber Roof Insulation Board
2. ASTM C728 Specification for Perlite Thermal Insulation Board
3. ASTM D312 Specification for Asphalt Used in Roofing
4. ASTM D2822 Specification for Asphalt Roof Cement
5. ASTM D3747 Specification for Emulsified Asphalt Adhesive for Adhering Roof Insulation
6. ASTM D4586 Specification for Asphalt Roof Cement, Asbestos-Free

B. Federal Specifications (FS):

1. TT-W-550 Wood Preservative, Chromated Copper Arsenate Mixture
2. TT-W-571 Wood Preservation: Treating Practices

C. Underwriters Laboratories (UL):

1. UL 580 Tests for Uplift Resistance of Roof Assemblies

2. UL 790 Tests for Fire Resistance of Roof Covering Materials

1.04 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Product Data: Submit manufacturer's product data of the roof deck insulation proposed for this work.

1.05 QUALITY ASSURANCE

A. Insulation and roofing shall meet Underwriters Laboratories requirements for Class A fire rating and Class I-90 wind uplift resistance in compliance with UL 790 and UL 580, respectively.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Roof Insulation: Roof deck insulation shall be of polyisocyanurate foam core laminated to glass reinforced mat facer. Furnish in thickness required to provide minimum thermal resistance, R value of 9, or as required and sufficient to span the flute of metal decking. Insulation shall be applied in at least two layers with staggered joints. Provide tapered roof insulation board where required for roof drainage. Tapered insulation can be of the same material as the deck insulation or a perlite-based material. Cover shall be perlite board conforming to the requirements of ASTM C728. Roof insulation material and insulation shall be compatible with the roofing system as recommended by the roofing materials manufacturer.

B. Adhesive: ASTM D3747.

C. Fasteners: Insulation board fasteners with appropriate stress-plate washers, manufactured specifically for securing insulation board to metal decking.

D. Roof Tape: Manufactured specifically for welding of tape over insulation joints, six inches wide.

E. Asphalt: ASTM D312, Type III.

F. Bituminous Plastic Cement: ASTM D2822 or ASTM D4586.

G. Wood Stops, Blocking, and Insulation-Containment Members: Pressure-treated "Construction" or "No.1" grade Douglas fir as specified in Section 06 10 00, Rough

Carpentry, treated with preservative in accordance with FS TT-W-550 for preservative material and FS TT-W-571 for pressure treating.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Coordinate roof insulation installation with the installation of roofing

B. Surfaces that insulation is to be applied shall be smooth and dry, free from loose particles, and shall be swept clean.

C. Install insulation board in accordance with the insulation manufacturer's installation instructions and recommendations. Apply boards with adjacent ends staggered not less than 24 inches.

D. Install perimeter wood containment members and stops with mechanical fasteners as indicated or required.

E. Mop boards into place using hot steep asphalt applied in ribbons on six inch centers; press firmly into place. Cut boards to fit neatly around vent pipes, curbs, vertical surfaces, and other deck projections.

F. Where required for additional holding power for holding boards in place, provide mechanical fasteners of type specified and installation method recommended by the fastener manufacturer.

G. Apply roof tape in hot asphalt over all joints of insulation board in accordance with the insulation and tape manufacturer's taped joint system specifications and recommendations. Apply roof tape over joints between adjacent insulation boards and between wood blocking or insulation stops and insulation boards. Broom roof tape into asphalt.

H. Lay no more boards than will be covered with completed roofing on the same day. Do not leave installed boards exposed to weather. Provide protection of insulation from rain and moisture.

I. Provide water cut-offs at exposed edges of insulation at end of day's work and whenever rain is imminent. Extend cut-offs six inches on roof deck, carry up and over roof insulation, and extend six inches on top of roofing. Remove before continuing installation of insulation.

END OF SECTION 07 22 00

SECTION 07 26 00

VAPOR RETARDERS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Polyvinyl chloride membrane sheeting.

B. Adhesive.

C. Tape.

1.02 RELATED SECTIONS

A. Aggregate drainage fill and sand cushion are specified in Section 32 11 24, Aggregate Drainage Layer.

1.03 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for vapor barrier will be either by the lump-sum method or by the unit-price method as determined by the listing of the bid item for vapor barrier indicated in the Bid Schedule of the Bid Form.

B. Lump Sum: If the Bid Schedule indicates a lump sum for vapor barrier, the lump-sum method of measurement and payment will be in accordance with Section 01 20 00, Price and Payment Procedures, Article 1.03.

C. Unit Prices: If the Bid Schedule indicates a unit price for vapor barrier, the unit-price method of measurement and payment will be as follows:

1. Measurement

    a. Vapor barrier will be measured for payment by the square yard or square foot complete in place.

    b. Adhesives, tape, and accessories will not be measured separately for payment; such items will be considered incidental to the vapor barrier installation and included in the measurement specified above.

2. Payment: Vapor barrier will be paid for at the Contract unit price for the computed quantities as determined by the measurement method specified in Article 1.03.C.1.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM D1593 Standard Specification for Nonrigid Vinyl Chloride Plastic Film and Sheeting

2. ASTM D4551 Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Flexible Concealed Water-Containment Membrane

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Samples: Submit representative samples of the polyvinyl chloride vapor barrier material, adhesive, and tape.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Vapor Barrier Sheeting: Polyvinyl chloride plastic membrane sheeting, meeting requirements of ASTM D1593 or ASTM D4551, 10 mils thick.

B. Adhesive: Synthetic rubber base cement, manufactured specifically for use with poly-vinyl chloride membrane material for cold application.

C. Tape: Pressure-sensitive neoprene or vinyl-chloride rubber adhesive tape as recommended by the manufacturer of the vapor barrier material or a heavy-duty cloth masking tape, minimum three inches wide; for sealing of laps and joints in vapor barrier sheets.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Lay vapor barrier sheets directly over compacted aggregate drainage fill (between compacted aggregate drainage fill and sand cushion) without damaging the sheets. Repair punctures and tears in vapor barrier sheets occurring during subsequent operations. Vapor barrier shall be continuous between footings or foundation walls, without voids.

B. Lap edges not less than four inches and ends not less than six inches, with all laps sealed continuously with adhesive and tape.

C. Turn up membrane a minimum of two inches or to within 1/2 inch of top of slab at edges and secure to wall foundations or footings with specified adhesive and tape.

D. Fit and seal vapor barrier tightly around pipes and conduits that penetrate the fill.

END OF SECTION 07 26 00

SECTION 07 52 16

MODIFIED BITUMEN ROOFING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Base sheet.

B. Cap sheet.

C. Base flashing.

D. Heat welded application.

E. Elastomeric coating.

F. Caulking sealant.

G. Mastic.

H. Parapet membrane flashing.

I. Walk pads.

1.02 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for modified bitumen roofing will be either by the lump-sum method or by the unit-price method as determined by the listing of the bid item for modified bitumen roofing indicated in the Bid Schedule of the Bid Form.

B. Lump Sum: If the Bid Schedule indicates a lump sum for modified bitumen roofing, the lump-sum method of measurement and payment will be in accordance with Section 01 20 00, Price and Payment Procedures, Article 1.02.

C. Unit Price: If the Bid Schedule indicates a unit price for modified bitumen roofing, the unit-price method of measurement and payment will be as follows:

1. Measurement

    a. Modified bitumen roofing, will be measured for payment by the square foot or square yard, as indicated in the Bid Schedule of the Bid Form, acceptably furnished and installed.

    b. Substrate preparation, installation accessories, flashings, protection of non-roofed areas from moisture, and protection of completed surfaces will not be measured separately for payment, but will be considered included with the measurement specified above.

2. Payment: Modified bitumen roofing, will be paid for at the Contract unit price for the computed quantities as determined by the measurement method specified in Article 1.03.

1.03 REFERENCES

A. American Society for Testing and Materials (ASTM):

1.	ASTM D41/D41M	Standard Specification for Asphalt Primer Used In Roofing, Dampproofing and Waterproofing
2.	ASTM D312/D312M	Standard Specification for Asphalt Used in Roofing
3.	ASTM D3019/D3019M	Standard Specification for Lap Cement used in Asphalt Roll Roofing, Non-Fibered, and Fibered
4.	ASTM D4586/D4586M	Standard Specification for Asphalt Roof Cement, Asbestos-Free
5.	ASTM D5147/D5147M	Standard Test Methods for Sampling and Testing Modified Bituminous Materials
6.	ASTM D6162/D6162M	Standard Specification for Styrene Butadiene Styrene (SBS) Modified Bituminous Sheet Materials Using Polyester and Glass Fiber Reinforcements
7.	ASTM C920	Standard Specification for Elastomeric Joint Sealants

1.04 REGULATORY REQUIREMENT

A. In addition to the reference standards, the regulatory requirements that govern the work of this Section include the following governing code:

1. California Code of Regulations (CCR), Title 24, Part 2, California Building Code, Chapter 15, “Roof Assemblies and Rooftop Structures”

1.05 ROOF SYSTEM DESCRIPTION

A. Modified bitumen roofing membranes, base flashing, insulation, and flashing at metalwork and roof penetrations shall meet or exceed the requirements of a two-ply heat-welded applied modified bitumen roofing system for which an approved single manufacturer can issue a 30-year No Dollar Limit (NDL) material and workmanship guarantee.

1.06 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Product Data: Submit manufacturer's specifications for materials and installation of the appropriate roofing system and related flashing, for review. Work shall not proceed until the manufacturer's specifications have been approved by the Engineer and returned to Contractor.

C. Samples: Submit two samples of square eight-inch by eight-inch for base and cap membrane, and base flashing.

D. Shop Drawings: Within 20 calendar Days of the effective date of the Notice to Proceed, submit the following for approval:

1. Shop drawings showing setting plan for the insulation including tapered insulation, layout of felts and flashing details.

E. Copy of valid and updated Certified Roofing Torch Applicator (CERTA) certificate for each worker that will use torch on Jobsite. CERTA training is offered by National Roofing Contractors Association (NRCA).

1.07 QUALITY ASSURANCE

A. Performance Requirements:

1. Roofing materials shall be furnished by a manufacturer specializing in the manufacture of roofing materials.

2. Roofing work and related flashings shall be installed by a licensed contractor approved by the manufacturer who furnishes the material. Contractor shall submit a valid "Certificate of Eligibility" from the selected roofing materials manufacturer.

3. Contract Drawings and Specifications for roofing and flashings are diagrammatic and of a general nature only. Therefore, the manufacturer's specifications and flashing details shall govern as fully as if set forth herein, except as specifically indicated otherwise. Work shall be completed as required to obtain the required warranty and guaranty.

4. The Contractor shall review the Contract Drawings and Specifications with the roofing materials manufacturer and shall obtain manufacturer's concurrence that the selected roofing, insulation and its installation procedures, and flashing system are proper, compatible, and adequate for this application, and that the conditions and details indicated do not conflict with the recommendations of the manufacturer.

5. The Contractor and roofing materials manufacturer shall determine the probability of thermal and structural movement in the roofing system and shall provide for expansion and contraction in the roofing system as required to provide a serviceable roof without failures.

6. The foreman and the crew shall be trained and follow the safety and application guidelines as outlined in the Certified Roofing Torch Applicator (CERTA) manual.

B. Roofing Manufacturer's Approval and Inspections:

1. Pre-roofing Conference: Contractor, roofing materials manufacturer's representative and the Engineer shall meet at the project site well in advance of the time schedules for roofing and other related work, and review requirements for the work and conditions which could possibly interfere with successful performance of the work.

2. Contractor shall arrange for the roofing materials manufacturer to render work-in-progress inspections to make certain that the materials used in the work are in accordance with these specifications, and they are being installed in accordance with this specification and the manufacturer's installation instructions and recommendations. Roofing materials manufacturer's inspector shall be present during the initial installation of insulation and placement of plies and intermittently thereafter at the inspector's discretion to assure the proper installation of roofing. At the completion of the job, promptly conduct final inspection with roofing materials manufacturer's representative and the Engineer. Manufacturer's inspector shall submit field reports and manufacturer's certification to the Engineer.

1.08 GUARANTY

A. Modified bitumen roofing and related flashing installations, including related metalwork, shall be guaranteed against leakage, defective materials, and defective installation of the completed roofing work. Any such defects or leakage occurring during the period of the guaranty shall be promptly and completely corrected, including affected work, at no additional expense to the District. Bulging or wrinkling of modified bitumen roof surfaces will also be interpreted as defects requiring correction.

B. In addition to the guaranty requirements specified in General Conditions Article GC4.9, provide the roofing manufacturer's thirty (30) year roofing system guaranty. Contractor will ensure that the District receives a proper transfer and assignment of the manufacturer's thirty (30) year roofing guarantee. The terms of this guarantee shall include provision that it is a "no dollar limit" guarantee, that it covers all the manufacturer's materials comprising the roof, and that the manufacturer will promptly repair the roof to a watertight condition in the event of (1) normal wear and tear, (2) any deficiencies in the component materials or (3) any deficiencies in the workmanship of the Contractor in the application of the roof.

C. Contractor shall provide a five-year workmanship guarantee against leaks and improper application including but not limited to defects such as: blisters, slippage, wrinkles, areas ponding water, granules loss, and shrinkage even if it hasn't resulted in leaks.

D. Guaranty shall list the correct building name, address, and contract number.

E. Manufacturer's Maintenance Agreement: Manufacturer shall inspect the building every four years for the duration of the warranty period. Each inspection shall include a written report on the condition of the roof and areas, and identification of the areas that need repair. A comprehensive report shall be prepared in digital and printed format and describe the condition of the roof. The report shall alert the District to areas that require maintenance. Manufacturer shall make repairs identified in the report and by the District representatives. Repairs shall be included under the warranty and performed at no cost to the District, even if they have not resulted in leaks. Items covered under warranty shall include granule loss, loose flashing, dried out mastic or caulking, blisters, mud cracking, wrinkles, edge metal separation, and damage to the roofing system due to ponding water. Damage to roofing membrane due to natural disasters including but not limited to earthquake and hail damage may be excluded from maintenance agreement.

F. Coating Manufacturer: Coating manufacturer shall issue a seven-year warranty against peeling, flaking, and cracking. The same company supplying and warranting the roofing membrane shall supply and issue the coating warranty.

1.09 OTHER REQUIREMENTS

A. Manufacturer shall submit proof of the following tests and requirements:

1. Fire Testing: Materials shall be tested to a minimum of Class A fire rating in compliance with UL 790 and must bear testing agency's (Underwriter's Laboratories, etc.) mark.

2. Wind Uplift: Roofing system shall be classified as Class 90 in compliance with UL 580.

1.10 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Roofing materials shall be delivered to the Jobsite in new, dry, unopened containers clearly showing catalog number, product description, manufacturer's name and location. Delivered quantities should be sufficient to assure continuous work.

B. Materials shall be kept clean and protected from exposure to excessive heat or cold. Materials shall be stored in an enclosed area where the temperature is above 50 degrees or below 90 degrees Fahrenheit. Materials shall not be set directly on the ground. Labels shall not be removed nor protective covering torn-off until ready for application.

C. Materials shall be protected from exposure to moisture in any form before, during, or after delivery to the site. Delivered materials showing evidence of contact with moisture shall be rejected.

D. Materials shall not be double stacked nor stacked in a manner that could overload the roof structure.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Roofing Membranes:

1. Smooth base membrane shall be premium fiberglass and polyester mat reinforced SBS (Styrene-Butadiene-Styrene) modified bitumen sheets conforming to or exceeding the requirements of ASTM D 6162, Grade S. These sheets shall be an elastomeric, asphaltic-blend product with a minimum thickness of 140 mils and roll weight of not less than 114 pounds per 100 square feet.

2. Cap shall be fire-resistant, premium fiberglass and polyester mat reinforced, white granular surfaced SBS (Styrene-Butadiene-Styrene) modified bitumen cap sheet conforming to or exceeding the requirements of ASTM D 6162, Grade G. Weight shall be at least 116 pounds per 100 square feet.

3. Base flashing shall be an elastomeric SBS modified bitumen sheet surfaced with factory applied white roofing granules. Base flashing shall meet or exceed the product specification of the cap.

B. Associated Materials: Obtain in writing the approval from the roofing materials manufacturer on the use of accessories used in assembly of the roofing system such that they are compatible and do not void the warranty.

1. Cants: Shall be fire-resistant, manufactured of compressed fiberglass or perlite board and/or fabricated of pressure treated Douglas Fir “Construction” or “No. 1” grade.

2. Pitch Pans, Expansion Joints, Metal Flashings: Shall be in compliance with NRCA and SMACNA application standards.

3. Pitch Pan Filler: Shall consist of a two component, cold applied urethane compound as approved by roofing membrane manufacturer.

4. Caulking Sealant: Shall consist of a single component, high performance, elastomeric compound, and conform to ASTM C920, Type S, Grade NS, Class 50.

5. Mastic: Elastomeric mastics, adhesives, and caulking products shall be used. Standard grade adhesive and mastics are not acceptable. Mastics shall conform to ASTM D4586.

6. Liquid reinforced flashing system: Flash single-component, elastomeric asphalt emulsion with polyester reinforcing fleece fabric fully embedded into the resin to form roof system flashings.

C. Coating: Elastomeric high-performance coating approved by the roofing manufacturer for use with the roofing system. Coating shall meet the California Code of Regulations (CCR), Title 24, Part 2, California Building Code, Chapter 15, "Roof Assemblies and Rooftop Structures".

PART 3 – EXECUTION

3.01 EXAMINATION

A. Examine roof deck insulation and other surfaces to receive roofing. These surfaces must be clean, smooth, flat, dry, and free from defects or irregularities, which can jeopardize the quality of the work. No roofing work shall be performed on defective areas until suitable corrections have been made.

B. Inspect and approve the installation of roof deck insulation, sheet metalwork, wood nailers, metal framing members, roof specialties and accessories in connection with the roofing work. Refer to Section 07 22 00, Roof and Deck Insulation, for roof deck insulation, refer to Section 07 60 00, Flashing and Sheet Metal, for metal flashing and sheet metalwork, refer to Section 07 70 00, Roof and Wall Specialties and Accessories, for roof specialties and accessories are in.

3.02 INSTALLATION

A. Membrane Application: Installation of roofing membranes shall be in accordance with the materials manufacturer’s specifications, instructions and recommendations for heat-welded two-ply modified bitumen application using only workers skilled and experienced in the installation of the type of work involved. Prior to application, Contractor shall review the specifications and the manufacturer’s technical manual with the manufacturer’s technical representative to make certain that all aspects of membrane application are understood.

B. A competent foreworker shall maintain constant supervision of the work.

C. Install only as much complete roofing system that can be completed in one working shift. No section of roof shall be left exposed and unfinished at the end of each shift.

D. Traffic shall be minimized on a freshly laid roof while material is bonding and hot.

E. At the end of each working day, Contractor shall install temporary water cut-offs where roofing membrane does not abut a wall, wood edge member, or an expansion joint. Water cut-offs shall be removed cleanly when work resume. Roofing materials manufacturer’s instruction shall be followed when installing water cut-offs.

F. Set penetrations in neoprene SBS flashing cement over the SBS base sheet per manufacturer’s specification.

G. Heat fuse a strip of base flashing membrane minimum 10 inch wide to the primed edge metal so that it extends minimum 4 inch beyond edge of the metal.

H. Heat fuse cap sheet over the stripped edge metal.

I. Apply pressure to the surface of fused flashing cap membrane to ensure adhesion and solid fusion.

J. Fill voids between the penetration and flashing collar with sealant.

K. Rolls (both ply and cap) shall not be put down in full-length rolls (33 lineal feet). They shall be cut to the following lengths:

1. Slopes of 1/4 inch to 1 1/2 inch: 17-foot max

2. Slopes of 1 1/2 inch to 2 inch: 11-foot max

L. Material shall be cut to specified lengths then relaxed or heated until the material lies completely flat before installation, with no wrinkles, no buckles, or rigid end strips.

M. Matching granules may be broadcast into the modified bitumen bleed out at seams while hot to enhance the finished appearance of the membrane.

N. End laps shall be staggered a minimum of 18 inches (457 mm) so that no adjacent end laps coincide. If end laps fall in line or are not staggered the proper distance, a full width of membrane shall be installed over the end laps. End laps, flashing sheets, and other seams formed over granule surfaces require pre-heating of the top surface of the underlying granule surface membrane to a point where the granules just begin to sink into, and the modified bitumen compound comes up through the granules to ensure proper seam construction and adhesion.

O. Laps shall be parallel or perpendicular to the slope of the roof such that the flow of water is not against the lap.

P. Parapet walls shall be wrapped up and over with the SBS membrane. System shall consist of a smooth membrane and granulated membrane fully adhered to a primed surface. A backer sheet is required with heat welded system. Termination bar shall be covered by metal coping as indicated.

Q. Walk pads shall be manufactured with recycled tire with a minimum thickness of 1/2 inch and approved by the manufacturer of the roofing membrane. Walk pads shall be installed along the access to and around each equipment requiring maintenance. Walk pads shall not obstruct the drainage. Walk pads shall be spaced minimum of two inches and maximum of ten inches apart from each other.

3.03 FIELD QUALITY CONTROL

A. After the completion of roofing and related work, a water ponding test shall be performed for all roof areas, parapets, curbs, penetrations, and accessories by applying a flood coat of water along the high areas so that water at least 1/4-inch deep flows over the areas. Tests shall be performed under the Engineer's observation.

B. Roof drains shall be temporarily plugged, and at least one inch of water shall be allowed to stand around the roof drain for one hour. Should a leak or low spot that ponds water appear, it shall be repaired, and the roof areas shall be retested until work is watertight.

C. Prior to applying membranes, the Contractor and its foreman shall review the specifications and the manufacturer's technical manual with the manufacturer's technical representative to make certain all aspects of membrane application are understood. Application shall proceed in strict accordance with specifications and detailed drawings and instructions in said technical manual. No verbal deviation will be accepted unless authorized on company's letterhead signed by the company's "Manager of Technical Services".

3.04 COATING APPLICATION

A. New granulated cap sheet can be coated no sooner than 21 days of original installation or longer as required by either SBS roofing manufacturer or coating manufacturer. Surface shall be dry and free of any debris.

B. Surface and air temperatures must be a minimum of 60 degrees Farenheit and rising. Application is not allowed if heavy dew or rain is expected within 24 to 48 hours. Apply on a clear, sunny day in morning hours with a 3/4 inch nap exterior paint roller or professional airless sprayer. First, apply one coat over seams and joints. Allow to cure to one hour or until dry, apply two uniform coats over entire surface, avoiding excessive rolling. Two full coats are required. Apply second coat perpendicular to first coat back rolling where necessary. Provide an additional two coats where standing water exists.

3.05 FIRE WATCH

A. Fire watch shall be provided continuously during and for at least two hours following torch application. At least two 2.5-gallon containers of water and two 4A60BC extinguishers shall be available during the fire watch. When work is interrupted, or at the end of a section of roofing, and at end of each day's work, areas that had been subjected to torch applications shall be surveyed with an infrared sensing device. Hot spots shall be cooled and re-surveyed. If a hot spot persists, the roof shall be cut open and any smoldering shall be extinguished before the Contractor leaves the Jobsite.

END OF SECTION 07 52 16

SECTION 07 60 00

FLASHING AND SHEET METAL

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Metal flashing and trim.

B. Gutters and downspouts.

C. Miscellaneous sheet metalwork.

1.02 RELATED SECTIONS

A. Copper roofing, including related copper gutters and downspouts, is specified in Section 07 61 00, Sheet Metal Roofing.

B. Sheet metal ductwork for air distribution systems is specified in Section 23 31 00, HVAC Ducts and Casings.

1.03 MEASUREMENT AND PAYMENT

A. General: Flashing and sheet metalwork will not be measured separately for payment but will be paid for as part of the Contract lump sum price for Architectural Work.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM A240/A240M Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications

2. ASTM A653/A653M Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-iron Alloy Coated (Galvannealed) by the Hot-Dip Process

3. ASTM A924/A924M Standard Specifications for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process

4. ASTM A968/A968M Standard Specification for Chromium, Chromium-Nickel, and Silicon Alloy Steel Bars and Shapes for Corrosion and Heat-Resisting Service

5. ASTM B29 Standard Specification for Refined Lead

6. ASTM B32 Standard Specification for Solder Metal

7. ASTM B209 Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate

8. ASTM B306 Standard Specification for Copper Drainage Tube (DWV)

9. ASTM B370 Standard Specification for Copper Sheet and Strip for Building Construction

10. ASTM C920 Standard Specification for Elastomeric Joint Sealant

B. Federal Specification (FS):

1. UU-B-790 Building Paper, Vegetable Fiber (Kraft, Waterproofed, Water Repellent and Fire Resistant)

C. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):

1. SMACNA Architectural Sheet Metal Manual

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings and Product Data: Submit detailed Shop Drawings of metal flashing and sheet metalwork, including gutters and downspouts, and installation details. Include manufacturers' product data for materials and manufactured items.

1.06 QUALITY ASSURANCE

A. Flashing and sheet metalwork shall be fabricated and installed in accordance with SMACNA Architectural Sheet Metal Manual.

B. Except where otherwise indicated, comply with minimum thickness or gage requirements as specified in SMACNA Architectural Sheet Metal Manual.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Galvanized Sheet Metal: Standard galvanized steel sheet, meeting requirements of ASTM A653/A653M and ASTM A924/A924M, as applicable, with minimum zinc coating of 1.25 ounces per square foot and 0.2 percent copper bearing, and mill phosphatized for maximum paint adherence. Where sheet metal gage is not indicated, provide 24 gage.

B. Stainless Steel: Stainless steel sheet for architectural applications, meeting the requirements of ASTM A240/A240M or ASTM A968/A968M, Type 304 or Type 316, with No. 4 finish. Where stainless steel sheet gage is not indicated, provide 26 gage.

C. Sheet Copper: Standard cold-rolled copper sheet for building construction, conforming with ASTM B370, 16 oz., 20 oz., 24 oz., or 32 oz. per square foot as indicated or required. Where copper weights are not indicated, provide 16 oz. Gutters and downspouts shall be fabricated from 24 oz. copper. Cleats shall be 32 oz. copper.

D. Copper Drainage Tube: Where downspouts are indicated as copper pipe or tube, provide DWV copper drainage tube conforming to ASTM B306. Provide for installation with standard copper, brass, or bronze fittings, as indicated, capable of being soldered. Coordinate with plumbing requirements specified under Division 22, Plumbing.

E. Aluminum Sheet Metal: ASTM B209, 5005 or 3003-H14 aluminum alloy as appropriate, clear anodized or epoxy coated. Where aluminum sheet thickness is not indicated, provide 0.0201 inch thickness.

F. Sheet Lead: Standard 0.062 inch thick lead sheet weighing 4 pounds per square foot, arsenical-antimonial and pig lead alloy meeting the requirements of ASTM B29. Use sheet lead or tubing for flashing of vent pipes and other penetrations of the roof.

G. Solder: Grade A meeting requirements of ASTM B32, composed of 50 percent pig lead and 50 percent block tin, warranted pure. Flux shall be an approved brand of soldering flux for the type of metal or muriatic acid neutralized with zinc.

H. Building Paper: Rosin sized, unsaturated paper, weighing approximately 6 pounds per 100 square feet, or a water-repellent smooth building paper meeting requirements of FS UU-B-790, Type I, Grade A.

I. Fasteners and Accessories: Furnish anchors and fasteners, washers, straps, and accessories required for a complete and finished installation. Fasteners and accessories shall conform with the following requirements:

1. Nails shall be stainless steel, hard copper, bronze, or brass. Where sheet metal is built in over roofing materials or other sheet metal, use nails or screws with 1 inch matching nonferrous washers. Screws shall be standard stainless steel, brass, or bronze wood screws, as required. Sheet metal screws shall be self-drilling, self-tapping stainless steel or tempered non-corrodible steel of proper size and length to suit conditions.

2. Screw heads shall be furnished with neoprene washers.

3. Straps: Straps and miscellaneous fastenings, where required, shall be stainless steel, half-hard copper, or half-hard 70-30 brass of size indicated or required. Where not indicated, provide straps of 1/16 inch thick by 1 inch wide size.

J. Sealant: Caulking or sealing compound shall be a silicone synthetic rubber elastomeric sealant which cures at normal temperature to a flexible firm rubber, tack

free, in gun grade consistency. Sealant shall be specially designed for adhesion to the surfaces to which it will be applied, and shall meet or exceed the minimum requirements of FS TT-S-230 or FS TT-S-1543 or ASTM C920, as applicable.

K. Isolating Material: Alkali-resistant bituminous paint or varnish.

2.02 FABRICATION AND SHOP PAINTING

A. Form and fabricate sheet metalwork as indicated and in accordance with the approved Shop Drawings and SMACNA Architectural Sheet Metal Manual. Properly reinforce sheet metalwork as required for strength and appearance.

B. Galvanized sheet metal surfaces which will be concealed in the finished work shall be chemically treated or etched to assure maximum paint adherence and then shop painted with one coat of an approved galvanized primer as specified in Section 05 50 00, Metal Fabrications. Finish field painting is specified in Section 09 91 00, Painting.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Installation Standards: Install flashing and sheet metalwork as indicated and in accordance with the approved Shop Drawings and SMACNA Architectural Sheet Metal Manual.

B. Flashing and Metal Trim: Provide flashing, counterflashing, cap flashing, metal trim, and any other fabricated items and miscellaneous sheet metalwork indicated or required to provide a complete and watertight installation.

C. Gutters and Downspouts: Install gutters and downspouts as indicated and in accordance with the approved Shop Drawings and pertinent provisions of SMACNA Architectural Sheet Metal Manual.

D. Work Quality:

1. Sheet metalwork shall be finished straight and true, with miters and joints accurately fitted. Exposed work shall be free of dents and other defects. Corners shall be reinforced and seams made waterproof. Edges of sheet metal shall be hemmed.

2. Provide for expansion and contraction in sheet metal assembly by means of expansion joints or other appropriate methods of SMACNA Architectural Sheet Metal Manual. Provide reinforcement as required.

3. Isolate and protect dissimilar metals from contact with each other by applying specified isolation material to contact surfaces. Protect surfaces of sheet metal in contact with concrete, treated wood, or aluminum with a heavy coating of bituminous paint.

4. Provide waterproof neoprene washers wherever required fasteners penetrate sheet metal. Exposed fasteners will not be permitted for any portion of this work.

E. Caulking and Sealing: Caulk or seal joints and laps of sheet metalwork as indicated or required for a waterproof installation. Beads of sealant which will be concealed in the finished work shall be continuous with no voids of material. Interface and coordinate the caulking and sealing work of this Section with the work specified in Section 07 90 00, Joint Protection.

F. Flashing for Roof Penetrations:

1. Flashing of roof penetrations shall be four pound lead. Flashing shall be accurately formed to conform with roofing contours and configurations and as required to assure a watertight installation. Flashing shall be built in as the roofing work progresses. Flash and burn lead against any penetrations through its surface.

2. Except as indicated otherwise, plumbing and mechanical vent flashing shall be of four pound lead tubing. Flanges shall be minimum 18 inches square, and tubing shall be long enough to permit turning lead into the end of vent pipe.

END OF SECTION 07 60 00

SECTION 07 61 00

SHEET METAL ROOFING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Copper sheet roofing.

B. Copper gutters, down spouts.

C. Copper flashing and trim.

1.02 MEASUREMENT AND PAYMENT

A. Measurement: Copper roofing, including gutters, downspouts, and related flashings, will be measured for payment by the lump-sum method, acceptably furnished and installed.

B. Payment: Copper roofing, including gutters, downspouts, and related flashings, will be paid for at the Contract lump-sum price as indicated in the Bid Schedule of the Bid Form.

1.03 REFERENCES

A. American Society for Testing and Materials (ASTM):

1.	ASTM B29	Standard Specification for Refined Lead
2.	ASTM B32	Standard Specification for Solder Metal
3.	ASTM B370	Standard Specification for Copper Sheet and Strip for Building Construction
4.	ASTM C920	Standard Specification for Elastomeric Joint Sealant
5.	ASTM D2178/ D2178M	Standard Specification for Asphalt Glass Felt Used in Roofing and Waterproofing

B. Federal Specification (FS):

1.	TT-S-230	Sealing Compound: Elastomeric Type, Single Component, Chemically Curing (For Caulking, Sealing, and Glazing in Buildings and Other Structures)
2.	TT-S-1543	Sealing Compound: Silicone Rubber Base (For Caulking, Sealing, and Glazing in Buildings and Other Structures)
3.	UU-B-790	Building Paper, Vegetable Fiber (Kraft, Waterproofed, Water Repellent and Fire Resistant)

C. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):

1. SMACNA Architectural Sheet Metal Manual

D. Underwriters Laboratories Inc. (UL)

1. UL 580 Standard for Safety Tests for Uplift Resistance of Roof Assemblies

2. UL 790 Standard for Standard Test Methods for Fire Tests of Roof Coverings

E. California Code of Regulations (CCR), Title 24, California Building Code, Part 2, Chapter 15, Roofs and Roof Structures

1.04 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings and Product Data: Submit detailed Shop Drawings of copper roofing and related gutters and downspouts and installation details for review. Include manufacturer's product data for copper materials and manufactured items. Include manufacturer's specifications and details for a pre-engineered, factory-manufactured roofing system.

C. Samples:

1. Submit two sample squares, eight by 10 inches in size, of the copper pan sheet.

2. Submit sample standing-seam or batten-seam assembly, as indicated.

3. Submit samples of anchors and mechanical fasteners proposed for use for the type of substrate.

1.05 QUALITY ASSURANCE

A. Codes and Standards:

1. Comply with applicable requirements of the California Building Code, Part 2, Chapter 15, Roofs and Roof Structures.

2. Roofing shall meet Underwriters Laboratories' requirements for Class A copper roofing assembly in compliance with UL 790 and Class 90 wind uplift resistance in compliance with UL 580.

3. Shop or site fabricated sheet copper roofing shall be fabricated and installed in accordance with SMACNA Architectural Sheet Metal Manual, applicable Charts and Plates, and related specifications.

4. Pre-engineered and factory-manufactured copper roofing shall meet all requirements specified herein and shall be installed in accordance with the roofing manufacturer's installation instructions and written recommendations

5. Supervise waterproofing underlayment and flashings of roof penetrations in connection with copper roofing work.

B. Performance Requirements:

1. Copper sheet roofing work, gutters and downspouts, and related flashings shall be fabricated and installed by a licensed subcontractor, skilled and experienced in the type of work involved.

2. The Contractor and copper roofing materials manufacturer or supplier/installer shall design roof-edge details to prevent wind-uplift and damage to the roof from high winds and storms.

3. The Contractor and copper roofing material manufacturer or supplier/installer shall determine the probability of thermal and structural movement in the roofing system and shall provide for expansion and contraction in the roofing system as required to provide a serviceable roof without failures.

4. Provide copper roofing capable of withstanding thermal expansion and contraction movements for an ambient temperature change of 150 degrees Fahrenheit. without failure, including air and water leakage, and without noise from metal-to-metal contact in movement.

C. Copper Roofing Manufacturer's Field Services:

1. Where the roofing is to be a pre-engineered, factory-manufactured roofing system, the copper roofing materials' manufacturer shall inspect and approve all copper roofing installations and shall provide field services at no additional cost to the District.

2. The Contractor shall make all necessary arrangements with the manufacturer of the materials to be installed to provide on-site consultation and inspection services to ensure the proper installation of the copper roof and related flashings.

3. The manufacturer's representative shall be present at the time any phase of the work is performed. Copper roofing shall be applied only over surfaces previously approved by the manufacturer's representative.

1.06 ENVIRONMENTAL CONDITIONS AND PROTECTION

A. Provide protection of all station and building roof areas from moisture and rain. Provide water-repellent coverings as required. Leave no unroofed deck areas exposed to moisture and rain at any time, prior to installation of roofing.

1.07 GUARANTY

A. Copper roofing and related flashing installations shall be guaranteed against leakage, defective materials, and inferior work quality of the completed work. Any such defects or leakage occurring during the period of the guaranty shall be promptly and completely corrected, including all affected work, at no additional cost to the District.

B. In addition to the guaranty requirements specified in General Conditions Article GC4.9, provide a five-year roofing system guaranty or warranty, which shall state in essence that the Contractor and roofing installer shall, at their expense, make or cause to be made any repairs necessary to maintain the applied roof and related flashings in a watertight condition for a period of five years. The guaranty shall be effective from the date of Substantial Completion, and shall be signed by the roofing installer and countersigned by the Contractor, and shall be submitted to the Engineer as specified in Section 01 77 00, Closeout Procedures.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Roof Type: Copper roofing system shall be of the type indicated, shop or site fabricated or factory-manufactured standing-seam or batten-seam system suitable for the site installation conditions. All materials for shop or site fabricated roofing system shall conform with the SMACNA Architectural Sheet Metal Manual. Site fabricated batten-seam roofs shall employ pressure-treated preservative wood battens. Factory-manufactured batten-seam roofs may employ a snap-on structural batten system of indicated profile.

B. Sheet Copper: Standard cold-rolled copper sheet for building construction, conforming with ASTM B370, 16 oz., 20 oz., 24 oz., or 32 oz. per square foot as indicated or required. Where copper weights are not indicated, provide 16 oz. copper sheet. Provide sheets in as long lengths as practical to minimize joints. Gutters and downspouts shall be fabricated of 24 oz. copper. Cleats shall be minimum 20 oz. copper. Copper finish shall be as indicated.

C. Sheet Lead: Standard 0.062-inch thick lead sheet weighing 4 pounds per square foot, arsenical-antimonial and pig lead and tubing alloy meeting the requirements of ASTM B29. Use sheet lead and tubing for flashing of vent pipes and other penetrations of the roof.

D. Solder: Grade A meeting requirements of ASTM B32, composed of 50 percent pig lead and 50 percent block tin, warranted pure. Flux shall be an approved brand of soldering flux for copper or muriatic acid neutralized with zinc.

E. Wood Nailers and Battens: Wood nailers and battens shall be “Construction” or “No. 1” grade Douglas fir, pressure-treated with preservative, as specified in Section 06 10 00, Rough Carpentry, of size and dimensions indicated or required. Moisture content shall not exceed 19 percent.

1. Anchors and Fasteners: Wood nailers and battens shall be anchored to metal decking with self-drilling, self-tapping, tempered steel screws manufactured for the purpose of securing items to metal decking. Screws shall be specially treated to prevent corrosion. Wood nailers and battens shall be anchored to concrete substrates with expansion-type anchors as specified in Section 05 50 00, Metal Fabrications.

F. Roofing Felt: Asphalt-saturated glass felt, conforming with ASTM D2178 and weighing 30 pounds per 100 square feet.

G. Building Paper (Slip Sheet): Rosin-sized, unsaturated paper, weighing approximately six pounds per 100 square feet, or a water-repellent smooth building paper meeting requirements of FS UU-B-790.

H. Fasteners and Accessories: Furnish anchors and fasteners, washers, straps, and accessories required for a complete and finished installation. Fasteners and accessories shall conform with the following requirements:

1. Nails shall be hard copper, bronze, or brass. Where sheet metal is built in over roofing materials or other sheet metal, use nails or screws with 1-inch copper washers. Rivets shall be soft copper rivets. Screws shall be standard brass or bronze wood screws, as required. Sheet metal screws shall be self-drilling, self-tapping stainless steel or tempered non-corrodible steel of proper size and length to suit conditions.

2. Screw heads shall be furnished with neoprene washers.

3. Straps: Straps and miscellaneous fastenings, where required, shall be half-hard copper or half-hard 70-30 brass of size indicated or required. Where not indicated, provide straps of 1/8-inch thick by 1-inch wide size.

I. Sealant: Caulking or sealing compound shall be a silicone synthetic rubber elastomeric sealant that cures at normal temperature to a flexible firm rubber, tack free, in gun grade consistency. Sealant shall be specially designed for adhesion to the surfaces to which it will be applied, and shall meet or exceed the minimum requirements of FS TT-S-230 or FS TT-S-1543 or ASTM C920, as applicable.

J. Dielectric Isolating Material: Alkali-resistant bituminous paint or varnish.

2.02 FABRICATION

A. Form and fabricate standing-seam copper roofing, gutters, downspouts, and related flashings as indicated and in accordance with the approved Shop Drawings and the SMACNA Architectural Sheet Metal Manual. Properly reinforce sheet copper roofing as required for strength and appearance.

PART 3 – EXECUTION

3.01 EXAMINATION AND PREPARATION OF SUBSURFACES

A. Examination of Roof Deck Surfaces: Before starting the installation of any roofing work, examine all surfaces that the copper roofing and flashings are to be applied.

B. Cleaning and Preparation of Subsurfaces: Surfaces that copper roofing and flashings are to be applied shall be dry, clean of dirt and dust. Surfaces shall also be free from sharp protrusions and defective surfaces which will prevent a level and plane installation. Fill all joints, cracks, or depressions in subsurfaces with patch or underlayment material recommended by the manufacturer of the copper roofing system components.

C. Responsibility: Nothing specified herein shall be construed as relieving the Contractor of full responsibility for the waterproof quality of the finished installation. Surfaces that copper roofing and flashings are to be applied shall be in proper condition in every respect for installation of the copper roofing and flashings.

D. Protection: Protect structures to be roofed from moisture and rain until completion and acceptance of the roofing work

3.02 INSTALLATION

A. Installation Standards:

1. Install shop or site fabricated standing-seam or batten-seam sheet copper roofing and related gutters, downspouts, and flashings as indicated and in accordance with the approved Shop Drawings and the SMACNA Architectural Sheet Metal Manual.

2. Install factory-manufactured copper roofing and related gutters, downspouts, and flashings as indicated and in accordance with the approved Shop Drawings and the materials' manufacturer's installation instructions and written recommendations.

B. Flashings and Metal Trim: Provide flashings, counterflashings, ridge flashings, metal trim, and any other fabricated items and miscellaneous copper sheet metalwork indicated or required to provide a complete and watertight installation.

C. Gutters and Downspouts: Install gutters and downspouts as indicated and in accordance with the approved Shop Drawings and pertinent provisions of the SMACNA Architectural Sheet Metal Manual.

D. Work Quality:

1. Standing-seam and batten-seam sheet copper roofing shall be finished straight and true. Exposed work shall be free of dents and other defects. Corners shall be reinforced and seams made waterproof. Edges of sheet copper shall be hemmed.

2. Provide for expansion and contraction in sheet copper roofing and gutters by means of expansion joints or other appropriate methods of the SMACNA Architectural Sheet Metal Manual. Provide reinforcement as required.

3. Isolate and protect dissimilar metals from contact with each other by applying a heavy coating of the specified isolation material to contact surfaces.

4. Provide waterproof neoprene washers wherever required fasteners penetrate sheet metal. Exposed fasteners will not be permitted for any portion of this work.

5. Gutters shall have bottoms that slope continuously from expansion joints to downspout outlets as indicated.

E. Caulking and Sealing: Caulk or seal joints and laps of sheet copper as indicated or required for a waterproof installation. Beads of sealant that will be concealed in the finished work shall be continuous with no voids of materials. Interface and coordinate the caulking and sealing work of this Section with the work specified in Section 07 90 00, Joint Protection.

F. Flashings for Roof Penetrations:

1. Flashings of roof penetrations shall be four-pound lead. Flashings shall be accurately formed to conform with roofing contours and configurations and as required to assure a watertight installation. Flashings shall be built in as the roofing work progresses. Flash and burn lead against any penetrations through its surface.

2. Except as indicated otherwise, plumbing and mechanical vent flashings shall be offour-pound lead tubing. Flanges shall be minimum 18-inches square, and lead tubing shall be long enough to permit turning lead into the end of vent pipe.

3.03 FIELD QUALITY CONTROL

A. After completion of copper roofing and related work, a water test shall be performed for all roof areas, penetrations, and accessories by applying a sheet of water along the ridge or other high areas. The test shall be performed under the Engineer’s observation.

B. Should a leak appear, it shall be repaired, and the roof areas shall be retested as specified above until all work is watertight and acceptable.

END OF SECTION 07 61 00

SECTION 07 70 00

ROOF AND WALL SPECIALTIES AND ACCESSORIES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Roof hatches.

B. Smoke vents.

C. Gravity vents.

D. Equipment roof curbs.

E. Reglets and counterflashings.

F. Metal fascia and gravel stops.

G. Fall protection anchorage

1.02 MEASUREMENT AND PAYMENT

A. General: Roof specialties and accessories will not be measured separately for payment but will be paid for as part of the Contract lump sum price for Architectural Work.

1.03 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM A240/A240M	Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
2. ASTM A653/A653M	Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
3. ASTM B209	Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
4. ASTM B370	Standard Specification for Copper Sheet and Strip for Building Construction
5. ASTM D4586/D4586M	Standard Specification for Asphalt Roof Cement, Asbestos-Free

B. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):

1. SMACNA Architectural Sheet Metal Manual

C. Underwriters' Laboratories Inc. (UL):

1. UL Building Materials Directory

2. UL 793 Standard for Safety Automatically Operated Roof Vents for Smoke and Heat

D. American National Standards Institute (ANSI)

1. ANSI/ASSE Z359 series standards

1.04 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit detailed Shop Drawings for the fabrication and installation of custom fabricated roof specialty and accessory units. Show jointing, anchorage, accessory items, and flashings.

C. Product Data: Submit manufacturer's or fabricator's standard drawings and installation instructions for each roof specialty and accessory unit required, including product data to indicate compliance with the Contract Documents.

D. Certification: Submit certification of fire-resistance ratings as required for smoke-vent assemblies.

PART 2 – PRODUCTS

2.01 FABRICATION REQUIREMENTS

A. Provide standard manufactured products for roof specialties and accessories as indicated, modified where necessary to meet requirements.

B. Custom fabricate units or components that are not available as standard manufactured products.

C. Fabricate each item in the shop as a complete unit for coordination with adjoining work. Provide mounting curb, anchorage and flashing flanges, offsets to accommodate insulation thicknesses, cant strips and nailers for roofing, expansion sleeves (concealed on exposed fascias), hardware and noncorrosive bearings for operating parts, and gaskets and sealant recesses as required to make the installation weathertight.

D. Where exposed fasteners are necessary, provide stainless steel self-tapping screws or bolts.

E. Wherever a fire-resistance rating is indicated for construction or surfaces that roof specialties or accessories are to be installed, provide an assembly of type and manufacture listed in the UL Building Materials Directory. Provide UL or equivalent Classification Marking or Label on each fire-rated assembly.

2.02 MATERIALS

A. Galvanized Sheet Metal: Standard galvanized steel sheet, meeting requirements of ASTM A653/A653M, with minimum zinc coating of 1.25 oz. per square foot and 0.2 percent copper bearing, and mill phosphatized for maximum paint adherence.

B. Stainless Steel: Stainless steel sheet for architectural applications, meeting the requirements of ASTM A240/A240M, Type 304 or Type 316, with No. 4 finish.

C. Aluminum Extrusions: Extrusions for reglets, fascia, and gravel stops, where indicated, shall be 6061-T6 aluminum alloy, with minimum thickness of 0.094 inch.

D. Aluminum Sheet Metal: ASTM B209, 5005 or 3003-H14 aluminum alloy as appropriate.

E. Copper: Standard cold-rolled copper sheet for building construction, conforming with ASTM B370, 24 oz. or 32 oz. per square foot as indicated or required.

F. Bituminous Plastic Cement: ASTM D4586.

2.03 ROOF HATCH (SCUTTLE)

A. Roof scuttles shall be of sizes indicated, furnished complete with all necessary hardware and installation accessories. Curb and cover shall be fabricated from 14 gage steel, and cover liner from 22 gage steel. Provide cover with rubber draft seal. Cover insulation shall be glass fiber, minimum 1 inch in thickness.

B. Roof scuttle shall be galvanized, treated for paint adherence, and shop coated with an approved metal primer before delivery.

C. Provide roof scuttle complete with required operating hardware, including positive snap latch with turn handles and padlock hasps inside and outside. Hardware shall be non-ferrous or zinc-plated.

2.04 SMOKE VENT

A. Provide smoke-relief vent hatch of type and size indicated, with automatic doo-opening operation, furnished complete with necessary installation accessories. Construct units of manufacturer’s standard gages of metal, designed for a live load of 40 pounds per square foot. Smoke vent shall be galvanized, treated for paint adherence, and shop coated with an approved baked-on corrosion-inhibitive metal primer.

B. Provide hatch doors with metal cover and cover liner, insulated with minimum one-inch thick glass fiber insulation, rubber gaskets, spring hinges loaded to open against 10 pounds per square foot wind load, automatic release mechanism with 160 degree Fahrenheit UL-listed fusible link, and manual release latch and pull device. Provide smoke vent with emergency release device.

C. Smoke vent shall be listed by Underwriters' Laboratories Inc. under "Standard for Safety Automatically Operated Roof Vents for Smoke and Heat," and shall be Factory Mutual approved to assure dependable performance.

2.05 GRAVITY VENTS

A. Provide gravity ventilators of throat size, free-air opening, and configuration as indicated. Units shall be manufactured of galvanized steel or aluminum, anodized or clear epoxy-coated. Units shall be weatherproof, and shall not permit the intrusion of water during inclement weather.

2.06 EQUIPMENT ROOF CURBS

A. Provide curb units and components for roof-mounted mechanical and electrical equipment of types and sizes as indicated, furnished complete with necessary installation accessories. Fabricate units from galvanized steel sheets, with joints and seams welded for weathertight construction. Use 14 gage steel, unless otherwise indicated. Provide integral counterflashing formed to receive built-up or single-ply roofing. Curb units shall be sized to carry weight of equipment to be supported.

B. Form walls vertically with flanges as indicated for anchorage to deck, ready to receive roof insulation and cant strips. Insulate walls of units with minimum one-inch thick rigid glass fiber insulation, set inside of metal wall. Provide 22 gage metal liner, extended through opening and flanged at lower edge as indicated. Use perforated or expanded metal for liner, to form sound-absorbing surfaces in unit.

C. Provide pressure-treated wood nailers of sizes indicated, anchored to top flanges of unit in accordance with manufacturer's standard details. If size is not indicated, provide nominal one-inch thick wood or plywood.

D. Curb metalwork shall be galvanized, treated for paint adherence, and shop coated with an approved baked-on corrosion-inhibitive prime coat, inside and out.

2.07 REGLETS AND COUNTERFLASHINGS

A. Reglets and counterflashings shall be stainless steel, as indicated.

B. Reglets shall be heavy-gage stainless steel of type and configuration indicated, of strength required to hold rigidly and securely spring-locked counterflashing.

C. Counterflashings shall be 26 gage stainless steel. Counterflashings shall be shop or factory formed so that the counterflashings shall mate with and lock rigidly into the reglets.

2.08 FASCIA AND GRAVEL STOPS

A. Provide shop-fabricated fascia and gravel-stop units of types, sizes, profiles, and materials indicated or specified, to form a complete and continuous weatherproof trim system at the edge of the roofing, complete with prefabricated corner units, expansion joints, and anchorage devices.

B. Form concealed units from manufacturer's standard metal gages, but not less than 20 gage steel.

C. Fabricate exposed fascia trim units from extruded aluminum of thickness, alloy, temper, and hardness recommended by the manufacturer. Extruded aluminum shall be protected with a coating of 0.5 mil clear methacrylate lacquer.

D. Fabricate exposed copper fascia, as indicated, from minimum 32 ounce copper sheet. Comply with applicable requirements and details of SMACNA Architectural Sheet Metal Manual.

2.09 FALL PROTECTION ANCHORAGE

A. Provide fall protection devices as indicated.

B. Fall protection anchorage shall meet the minimum requirements related to anchorage and leading edge work of Cal-OSHA Article 24 and ANSI Z-359 series standards.

C. Furnish certification that the installed system complies with the requirements set forth by the applicable federal, state, and local regulations governing the fall protection equipment.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Examine substrate surfaces and components to receive roof specialties and accessories and correct conditions detrimental to the proper and timely completion of the work. Do not proceed with installation work until unacceptable conditions have been corrected and accepted.

3.02 INSTALLATION

A. Install roof specialty and accessory units as indicated and in accordance with the respective manufacturer's installation instructions. Install each unit plumb and level, true to line, and coordinated with adjacent related work. Anchor accessories securely to the substrate. Set flanges of units in bituminous plastic cement, and leave surfaces smooth and clean for application of roofing and flashing.

B. Installation shall be coordinated and integrated with roofing work, properly flashed, and shall be watertight upon completion.

END OF SECTION 07 70 00

SECTION 07 81 16

CEMENTITIOUS FIREPROOFING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Cementitious direct spray-applied fireproofing.

1.02 MEASUREMENT AND PAYMENT

A. General: Sprayed-on cementitious fireproofing will not be measured separately for payment but will be paid for as part of the Contract lump sum price for Architectural Work.

1.03 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM E84 Standard Test Method for Surface Burning Characteristics of Building Materials
2. ASTM E119 Standard Test Method for Fire Tests of Building Construction and Materials
3. ASTM E605/ E605M Standard Test Methods for Thickness and Density of Sprayed Fire-Resistive Material (SFRM) Applied to Structural Members
4. ASTM E736/ E736M Standard Test Method for Cohesion/Adhesion of Sprayed Fire-Resistive Materials Applied to Structural Members
5. ASTM E759/ E759M Standard Test Method for Effect of Deflection on Sprayed Fire-Resistive Material Applied to Structural Members
6. ASTM E760/ E760M Standard Test Method for Effect of Impact on Bonding of Sprayed Fire-Resistive Material Applied to Structural Members
7. ASTM E761/ E761M Standard Test Method for Compressive Strength of Sprayed Fire-Resistive Material Applied to Structural Members
8. ASTM E859/ E859M Standard Test Method for Air Erosion of Sprayed Fire-Resistive Materials (SFRMs) Applied to Structural Members
9. ASTM E937/ E937M Standard Test Method for Corrosion of Steel by Sprayed Fire-Resistive Material (SFRM) Applied to Structural Members
10. ASTM G21 Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi

B. Underwriters Laboratories Inc. (UL):

1. UL Fire Resistance Directory; applicable UL Design Numbers for application of spray-applied fireproofing and conditions as indicated.

C. National Fire Protection Association (NFPA):

1. NFPA 101, Life Safety Code Section 10.2.3.4.1 Class A Interior Wall and Ceiling Finish

1.04 SYSTEM DESCRIPTION

System includes one-hour, two-hour, and three-hour fire-rated protection for structural steel members and for underside of steel decking as indicated

1.05 REGULATORY REQUIREMENTS

A. In addition to the foregoing referenced standards, the regulatory requirements that govern the work of this Section include the following governing code:

1. California Code of Regulations (CCR), Title 24, Part 2, California Building Code (CBC), Chapter 7, “Fire and Smoke Protection Features”

1.06 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Product Data: Submit manufacturer’s product data of the cementitious fireproofing material proposed for this work.

C. Certificates: Submit certificates from a testing laboratory acceptable to the Engineer, attesting that fire protection material and installation methods meet specified fire hazard classifications and fire resistance ratings. Certificates shall also list thicknesses and density of material proposed for use.

1.07 QUALITY ASSURANCE

A. Regulatory Requirements: Spray-applied fireproofing shall meet or exceed the applicable requirements of the California Building Code, Chapter 7, “Fire and Smoke Protection Features,” and the applicable UL Design Numbers and code approvals for the application of the one-hour, two-hour, and three-hour fire protections indicated.

B. Qualifications: Application of the spray-applied fireproofing material shall be by a skilled and experienced applicator specializing in the application of spray-applied fireproofing. Fireproofing applicator shall be approved by the manufacturer who furnishes the materials. Submit proof of this in writing to the Engineer before starting the fireproofing application.

C. Manufacturer's Field Services:

1. The Contractor shall make necessary arrangements with the manufacturer of the materials to be applied to provide on-site consultation and inspection services to ensure the proper application of the cementitious fireproofing material.

2. At completion of the work, the manufacturer shall submit written certification that fireproofing material was applied over inspected and approved base steel components and that fireproofing material was applied correctly in accordance with these Specifications and the manufacturer's specifications and recommendations.

1.08 DELIVERY AND STORAGE

A. Materials shall be delivered to the site in sealed packages properly marked and labeled to show manufacturer's name, brand, and certification of compliance with requirements for fire hazard and fire-resistance classifications. Damaged packages found unsuitable for use in the work will be rejected and shall be removed from the site. Store materials under cover in a dry location.

1.09 PROJECT CONDITIONS

A. Surfaces that fire protection material is to be applied, as well as the ambient temperature during application and for 24 hours after application, shall not fall below 45 degrees Fahrenheit. Relative humidity shall be low enough to assure proper drying of the applied material.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Fireproofing Material: Factory-blended, cementitious direct spray-applied, non-flaking and non-dusting, type fireproofing material, with mold and fungi inhibitor added by the manufacturer. Fireproofing material shall be labeled by the UL, for fire hazard classification, and evidence of the UL Classification Marking shall appear on the packages of all fireproofing material. Material containing asbestos will not be acceptable. Material shall contain the following properties and characteristics:

1. Fire-Retardant Requirements: Fireproofing material shall have been tested, classified, and listed by the Underwriters Laboratories Inc. in accordance with the provisions of ASTM E119.

   a. Surface Burning Characteristics: Fireproofing material shall have a flamed-spread rating of 10 or less and a smoke-developed contribution of 0, according to NFPA 101, Section 10.2.3.4.1 Class A Interior Wall and Ceiling Finish, when tested in accordance with ASTM E84.

2. Applied Dry Density: Provide for minimum dry density in place, when tested in accordance with ASTM E605/E605M, as required by applicable UL Design Number for the indicated application.

3. Bond Strength: Minimum bond strength between fireproofing material and steel members shall be 200 pounds per square foot when tested in accordance with ASTM E736/E736M.

4. Deflection: Material shall not crack or delaminate from the surface that it is applied when tested in accordance with ASTM E759/E759M.

5. Bond Impact: Material shall not crack or delaminate from the surface that it is applied when tested in accordance with ASTM E760/E760M.

6. Compressive Strength: Material shall not deform more than 10 percent when subjected to compressive forces of 500 pounds per square foot in accordance with test requirements of ASTM E761/E761M.

7. Air Erosion: Maximum allowable weight loss of the material shall be 0.025 grams per square foot when tested in accordance with ASTM E859/E859M.

8. Corrosion Resistance: Applied material shall not promote corrosion of steel when tested in accordance with ASTM E937/E937M.

9. Fungi Growth Resistance: Applied material shall not support mold growth when tested in accordance with ASTM G21.

B. Water: Fresh, clean and potable, and free from such amounts of mineral and organic substances as would adversely affect the strength, cohesion, and adhesion of the fireproofing material.

2.02 MIXING

A. Mixing of fireproofing materials shall be in accordance with the manufacturer's instructions and recommendations. Material and water ratio shall be mechanically controlled.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Verify that items that will penetrate fireproofing, including clips and hangers for suspended ceilings, piping, and conduits are properly located and installed.

B. Verify that interfacing installations are complete as indicated.

3.02 PREPARATION OF SURFACES

A. Surfaces that spray-on fireproofing will be applied shall be cleaned of oil, grease, dirt, loose paint, mill scale, or any other matter that may impair bond of fireproofing material to steel. Galvanized decking material with lubricant shall be solvent washed and dried before application of fireproofing.

B. Provide suitable templates, masking, or coverings to stop fireproofing material and overspray at exposed finished surfaces in sharp and neat straight lines. Provide for protection of floors and equipment from spillage, overspray, and rebound.

3.03 APPLICATION

A. Application of fireproofing materials shall be in accordance with the application instructions and recommendations of the materials' manufacturer and the fire test reports' information. Adhesive and sealer, when not an integral part of the material, shall be applied in accordance with manufacturer's recommendations.

B. Fireproofing material shall be applied in minimum thicknesses as required to meet UL Design requirements and code approvals for one-hour and two-hour fire protections as indicated.

C. When test reports require tamping of sprayed-on material, provide such tamping in accordance with the manufacturer's instructions and recommendations.

3.04 PATCHING AND REPAIRING

A. Perform patching and repairing of fireproofing material as required to provide the one-hour, two-hour, and three-hour fire protection and related thicknesses. Include all patching and repairing of fireproofing material required after the work of other trades has been installed, such as piping and conduits, ductwork, metal stud partitions, ceiling suspension systems, and similar work. Re-apply fireproofing material as required to maintain fire-resistive continuity.

3.05 FIELD QUALITY CONTROL

A. Corrective measures, when necessary, shall be performed as required. The Contractor shall require that the manufacturer of the fireproofing material submit recommendations for corrective measures to the Engineer for approval.

B. The Contractor shall take frequent, random probe measurements, as witnessed by the Engineer, of applied material to verify compliance with thickness requirements.

C. The Contractor shall take field samples of fireproofing material, randomly selected, for laboratory tests to verify compliance with specified density and compressive-strength requirements. Submit such laboratory reports to the Engineer for record purposes.

END OF SECTION 07 81 16

SECTION 07 81 24

INTUMESCENT FIREPROOFING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Epoxy-based intumescent fireproofing.

B. Decorative topcoat finish.

C. Primer.

1.02 SYSTEM DESCRIPTION

A. System includes one hour and two hour fire-rated protection for structural steel members as indicated.

B. Fireproofing material shall be an epoxy-based intumescent fireproof coating. Provide decorative topcoat for exposed portions of structural steel only.

1.03 RELATED SECTIONS

A. Compatible primer for structural steel is specified in Section 05 12 00, Structural Steel Framing.

1.04 MEASUREMENT AND PAYMENT

A. General: Intumescent fireproofing will not be measured separately for payment but will be paid for as part of the Contract lump sum price for Architectural Work.

1.05 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM E84 Standard Test Method for Surface Burning Characteristics of Building Materials

2. ASTM E119 Standard Test Methods for Fire Tests of Building Construction and Materials

B. The Society for Protective Coatings (SSPC):

1. Steel Structures Painting Manual, Volume 2, “Systems and Specifications”

2. SSPC-PA 2 Procedure for Determining Conformance to Dry Coatings Thickness

C. Underwriters Laboratories Inc. (UL):

1. UL Fire Resistance Directory; applicable UL Design Numbers for application of fireproofing and conditions as indicated.

D. National Fire Protection Association (NFPA):

1. NFPA 101, Life Safety Code, Section 10.2.3.4.1 Class A Interior Wall and Ceiling Finish

1.06 REGULATORY REQUIREMENTS

A. In addition to the foregoing referenced standards, the regulatory requirements that govern the work of this Section include the following governing code:

California Code of Regulations (CCR), Title 24, Part 2, California Building Code, Chapter 7, “Fire and Smoke Protection Features.”

1.07 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Product Data: Submit manufacturer’s product data of the intumescent fireproofing material proposed for this work, indicating product characteristics, performance, and limitations. Include topcoat coating material and color samples for exposed steel surfaces.

1. Color of the topcoat in exposed locations requires the approval of the Engineer before the topcoat may be used in the work.

C. Certificates: Submit certificates from an independent testing laboratory, attesting that fire protection material and installation methods meet specified fire hazard classifications and fire resistance ratings.

1.08 QUALITY ASSURANCE

A. Regulatory Requirements: Intumescent fireproofing shall meet or exceed the applicable requirements of the California Building Code, Chapter 7, and the applicable UL Design Number and code approval for the application of the one-hour and two-hour fire protection indicated.

B. Qualifications: Application of the intumescent fireproofing material shall be by a skilled and experienced applicator specializing in the application of intumescent fireproofing. Fireproofing applicator shall be approved by the manufacturer who furnishes the materials.

C. Manufacturer's Field Services:

1. The Contractor shall make necessary arrangements with the manufacturer of the materials to be applied to provide on-site consultation and inspection services to ensure the proper application of the intumescent fireproofing material.

2. At completion of the work, the manufacturer shall submit written certification that fireproofing material was applied over inspected and approved base steel components and that fireproofing material was applied correctly in accordance with these Specifications and the manufacturer's specifications and recommendations.

1.09 DELIVERY AND STORAGE

A. Materials shall be delivered to the site in sealed containers properly marked and labeled to show manufacturer's name, brand, and certification of compliance with requirements for fire hazard and fire resistance classifications. Damaged containers found unsuitable for use in the work will be rejected and shall be removed from the site. Store materials under cover in a dry location.

1.10 PROJECT CONDITIONS

A. Surfaces to which fire protection material is to be applied, as well as the ambient temperature during application and for 24 hours after application, shall not fall below 50 degrees Fahrenheit. Relative humidity shall be low enough to assure proper drying of the applied material.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Fireproofing Material: Epoxy-based intumescent fireproofing material for spray or brush application, with a dry film thickness of not less than 0.26 inch as required to achieve the specified one-hour and two-hour fire-resistive ratings. Fireproofing material shall be labeled by the Underwriters' Laboratories, Inc., for fire hazard classification, and evidence of the UL Classification Marking shall appear on the containers of all fireproofing material. Material containing asbestos will not be acceptable. Material shall contain the following properties and characteristics:

1. Fire-Retardant Requirements: Fireproofing material shall have been tested, classified, and listed by the Underwriters Laboratories Inc. or Warnock Hersey in accordance with the provisions of ASTM E119.

2. Surface Burning Characteristics: Fireproofing material shall have a flame-spread rating of 25 or less, according to NFPA 101, Section 10.2.3.4.1 Class A Interior Wall and Ceiling Finish when tested in accordance with ASTM E84.

3. VOC Regulations: Fireproofing material shall comply with applicable California VOC Regulations as specified in Section 01 60 00, Product Requirements.

B. Decorative Topcoat Finish Material: Provide topcoat coating material for exposed steel as recommended by the fireproofing material manufacturer in color as selected by the Engineer.

C. Primer: Factory-applied primer with adhesion and compatibility characteristics necessary for the successful application of the fireproofing material as specified in Section 05 12 00, Structural Steel Framing.

2.02 MIXING

A. Mixing of fireproofing materials shall be in accordance with the manufacturer's instructions and recommendations.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Verify that items that will penetrate fireproofing, including clips and hangers for piping and conduits, are properly located and installed.

B. Verify that interfacing installations are complete as indicated.

3.02 PREPARATION OF SURFACES

A. Surfaces to which intumescent fireproofing will be applied shall be cleaned of oil, grease, dirt, loose paint, mill scale, or any other matter that may impair bond of fireproofing material to steel.

B. Provide suitable templates, masking, or coverings to stop fireproofing material and overspray at exposed finished surfaces in sharp and neat straight lines. Provide for protection of floors and equipment from spillage and overspray.

3.03 APPLICATION

A. Application of fireproofing materials shall be in accordance with the application instructions and recommendations of the materials' manufacturer and the fire test reports' information.

B. Fireproofing material shall be applied in minimum thickness of 0.26 inch and as required to meet UL Design requirements and code approval for one-hour and two-hour fire protection of structural steel.

C. Apply decorative finish coating over intumescent fireproofing for exposed steel surfaces in accordance with the manufacturer's application instructions and recommendations.

3.04 PATCHING AND REPAIRING

A. Perform patching and repairing of fireproofing material as required to provide the one-hour and two-hour fire protection and related thickness. Include all patching and repairing of fireproofing material required after the work of other trades has been installed, such as piping and conduits, ductwork, and similar work. Re-apply fireproofing material as required to maintain fire-resistive continuity.

3.05 FIELD QUALITY CONTROL

A. Corrective measures, when necessary, shall be performed as required. The Contractor shall require that the manufacturer of the fireproofing material submit recommendations for corrective measures to the Engineer for approval.

B. The Contractor shall take frequent, dry film thickness (DFT) readings of applied material to verify compliance with thickness requirements. Measurements shall be taken in accordance with SSPC-PA 2, Procedure for Determining Conformance to Dry Coatings Thickness. Submit report of such measurements to the Engineer for record purposes.

END OF SECTION 07 81 24

SECTION 07 84 00

FIRESTOPPING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Mineral fiber safing insulation.

B. Silicone foam seal system.

C. Gypsum fireproofing sealant.

D. Fire stop sealant.

1.02 SYSTEM DESCRIPTION

A. System includes specifications for firestopping and fire-resistant penetration seals for floors, walls, ceilings, and roof where fire-rated walls, shafts, or assemblies are penetrated by plumbing, mechanical, and electrical features, or otherwise, as indicated or required.

1.03 MEASUREMENT AND PAYMENT

A. General: Firestopping will not be measured separately for payment but will be paid for as part of the Contract lump sum price for Architectural Work.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM C475/ C475M — Standard Specification for Joint Compound and Joint Tape for Finishing Gypsum Board
2. ASTM E119 — Standard Test Methods for Fire Tests of Building Construction and Materials
3. ASTM E814 — Standard Test Method for Fire Tests of Penetration Firestop Systems.

B. Underwriters Laboratories Inc. (UL):

1. Building Materials Directory
2. Fire Resistance Directory

C. Warnock Hersey (WH):

1. Building Products Directory

1.05 REGULATORY REQUIREMENTS

A. In addition to the foregoing referenced standards, the regulatory requirements that govern the work of this Section include the following governing code:

1. California Code of Regulations (CCR), Title 24, Part 2, California Building Code, Chapter 7, “Fire and Smoke Protection Features.”

1.06 QUALITY ASSURANCE

A. Materials and installation shall meet or exceed the following requirements:

1. UL or WH Classification and Listing.

2. One-hour and two-hour fire ratings when tested in accordance with ASTM E119.

3. Class 1 (25 or less) flame-spread rating when tested in accordance with ASTM E814.

1.07 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit details of firestopping and through-penetration firestopping for indicated installations.

C. Product Data: Submit product data and installation instructions for indicated applications.

D. Record Documents: Indicated on record (“as-built”) documents locations of each type of firestopping.

1.08 SITE CONDITIONS

A. Follow manufacturer's instructions for temperature, ventilation, and other conditions required for proper mixing and installing of foam seals and sealants.

1.09 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials in the manufacturer's original unopened containers or packages with manufacturer's name, labels, product identification, lot numbers, and mixing and installation instructions, as applicable.

B. Store materials in the original, unopened containers or packages, and under conditions recommended by the manufacturer.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Requirements: Fire-stopping materials and fire-resistant penetration seals shall conform with the following types, as applicable for the location:

1. Mineral Fiber: Loose or batt mineral-fiber safing insulation, meeting fire-rating and installation requirements indicated.

2. Foam: One-part or two-part silicone foam, manufactured silicone penetrating seal system, meeting fire-rating and installation requirements indicated.

   a. Color for exposed locations shall be as selected by the Engineer from manufacturer's standard colors.

   b. Wherever seals are not exposed to view, provide manufacturer's standard color that has the best overall performance characteristics for the application indicated.

   c. Associated adhesive sealant, damming materials, and solvent shall be as recommended by the foam manufacturer.

3. Gypsum Fireproofing Sealant: Trowelable gypsum compound meeting applicable requirements of ASTM C475/C475M and ASTM E814 for one-hour or two-hour fire rating as indicated for the fire-rated assembly being penetrated.

B. Fire Stop Sealant: Sealant for the sealing of joints packed with mineral fiber or safing insulation shall be fire stop sealant manufactured for the purpose, meeting fire-rating and installation requirements indicated.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Examine penetrations and openings to be sealed to determine if conditions are satisfactory for the proper installation of fire-resistant materials and seals. If unsatisfactory conditions exist, do not commence work until such conditions have been corrected.

B. Verify that items and apparatus penetrating openings are installed and completed before beginning the firestop installation.

3.02 LOCATIONS

A. Provide firestopping and fire-resistant penetration seals wherever required to preserve fire ratings of building elements at plumbing, mechanical, electrical, and other penetrations.

3.03 INSTALLATION

A. Install materials in clean, dry openings free of loose material and projections.

B. Install materials in accordance with the respective manufacturer's installation instructions, and as required to provide a tight seal and preserve fire ratings at penetrations and openings.

C. Inspect foam seals following 24-hour cure; add additional foam as required for tight seal; reinspect and add foam until installation is satisfactory.

D. Install sealant in accordance with manufacturer's installation instructions.

3.04 CLEANING

A. Remove spilled and excess materials adjacent to penetrations without damaging adjacent surfaces.

B. Leave finished work in neat, clean condition with no evidence of spillovers or damage to adjacent surfaces.

END OF SECTION 07 84 00

SECTION 07 90 00

JOINT PROTECTION

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Sealants.

B. Primer.

C. Sealant backing.

D. Bond breaker.

1.02 SYSTEM DESCRIPTION

A. The work includes caulking and sealing of joints as required to seal the perimeters of openings in walls, penetrations in walls, expansion and control joints, and as required to weatherproof the station structure and other buildings.

B. The work includes interior building sealing of joints, penetrations, and openings, including acoustical and sanitary sealing, as indicated and required.

1.03 RELATED SECTIONS

A. Joint fillers and sealants for concrete slabs and paving are specified in Section 03 15 00, Concrete Accessories.

B. Control joints in unit masonry are specified in Section 04 22 00, Concrete Unit Masonry.

C. Expansion controls assemblies and covers for major expansion and seismic joints are specified in Section 07 95 00, Expansion Control.

D. Glazing sealant and accessories are specified in Section 08 80 00, Glazing.

1.04 MEASUREMENT AND PAYMENT

A. General: Sealants and caulking will not be measured separately for payment but will be paid for as part of the Contract lump sum price for Architectural Work.

1.05 DEFINITIONS

A. Sealant and caulking terms specified herein comply with the definitions of ASTM C717.

B. For the work of this Section, “interior” or “interior locations” are defined as not open to the exterior. Rooms and spaces such as the station concourse and platform are open to the exterior and shall be considered as exterior spaces.

1.06 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM C717 Standard Terminology of Building Seals and Sealants
2. ASTM C834 Standard Specification for Latex Sealants
3. ASTM C919 Standard Practice for Use of Sealants in Acoustical Applications
4. ASTM C920 Standard Specification for Elastomeric Joint Sealants
5. ASTM C1193 Standard Guide for Use of Joint Sealants

B. Federal Specifications (FS):

1. TT-S-230 Sealing Compound: Elastomeric Type, Single Component (for Caulking, Sealing, and Glazing in Buildings and Other Structures)
2. TT-S-1543 Sealing Compound, Silicone Rubber Base (for Caulking, Sealing, and Glazing in Buildings and Other Structures)

C. Underwriters Laboratories Inc. (UL):

1. UL 1479 Standard for Fire Tests of Penetration Firestops

1.07 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Samples: Submit samples of each type of exposed sealant and caulking compound, keyed to the installation location. Provide fully cured samples, 12 inches long, installed between two samples of the materials to be sealed.

C. Certification: Submit manufacturer’s certificate of compliance indicating that each product to be furnished complies with these Specifications, is recommended for the application indicated, and is compatible with the other materials in the joint system.

1.08 QUALITY ASSURANCE

A. Qualifications: Application/installation of sealant and caulking materials shall be by a licensed applicator skilled and experienced in the application/installation of sealants and caulking compounds.

B. Compatibility Tests: Primers and sealants shall be tested by the manufacturer for compatibility and adherence with materials to which application is indicated. Submit test reports certifying compatibility at least 30 Days before application.

C. Field Samples and Mock-Ups:

1. Provide sample application of sealants and caulking compounds at locations approved by the Engineer. Samples shall represent primary types of materials, substrate surfaces, joint size, exposure, and other conditions to be encountered in the work. Preparation, priming, application, and curing shall comply with manufacturer's recommendations for the actual conditions.

2. Samples will be visually examined for staining, dirt pickup, shrinkage, color, work quality, and appearance. Cut and pull sealant from each sample joint to examine for internal bubbles or voids, adhesion, and compatibility with substrate.

3. Schedule applications, with allowance for sufficient curing time, so that samples may be examined, and necessary adjustments made at least one week before date scheduled for commencing installation of the work.

1.09 SITE CONDITIONS

A. Do not proceed with installation of sealants and caulking compounds during inclement weather unless the installation complies with the manufacturer's instructions.

B. Do not proceed with the installation of sealants under extreme temperature conditions that may cause joint openings to be near either maximum or minimum width, nor when high temperatures or high wind loads are forecast during the period required for initial or nominal cure of elastomeric sealants.

C. Schedule installation and cure of elastomeric sealants during period of relatively low temperatures (but well within manufacturer's recommended range) so that subsequent tensile stresses upon cured sealants will be minimized.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Sealants: Sealants shall be designed for adhesion to the surfaces to which they will be applied, and shall be non-staining, non-shrinking, and non-sagging, meeting the following requirements:

1. Exterior Sealant: Sealant for exterior locations shall be a silicone or polyurethane elastomeric sealant, as appropriate for the substrate conditions, meeting requirements of ASTM C920, Type S or M, Grade NS, Class 25, and use designation as required for the location and substrate.

    a. Silicone Sealant: ASTM C920 and Fed. Spec. TT-S-230 or Fed. Spec. TT-S-1543, as applicable.

    b. Polyurethane Sealant: ASTM C920 or Fed. Spec. TT-S-230, as applicable.

2. Interior Sealant: Sealant for general sealing of interior locations shall be a single-component, gun-grade, paintable, water-base acrylic-latex, meeting requirements of ASTM C834.

3. Acoustical Sealant: Permanently plastic, paintable, synthetic polymer base sealant manufactured specifically for interior acoustical applications.

4. Sanitary Sealant: Single-component, primerless, flexible, mildew-resistant, silicone rubber, meeting requirements of ASTM C920 and Fed. Spec. TT-S-1543.

5. Fire-Resistant Sealant: Sealants used at penetrations of fire-rated walls and ceiling assemblies shall be UL listed as meeting UL 1479.

6. Sealant for Dielectric Insulation at Platform Edge Units: The electrical resistance of a 6 by 6-inch sample of sealant material shall be a minimum of 500 MΩ when tested with a 1 kV dc tester. Test shall be performed by placing the sample between two 3 by 3-inch copper electrodes. The sample shall be soaked in water 24 hours immediately prior to the test and surface dried prior to testing. Sample thickness shall be 1/2 inch.

7. Color:

    a. For fully concealed joints, provide manufacturer’s standard color of sealant or caulking compound that has best overall performance characteristics for application indicated.

    b. For exposed joints, provide color indicated or, if color is not indicated, provide colors as selected by the Engineer from manufacturer’s standard colors, to match or blend with adjoining materials or to match adjacent joint material as applicable.

B. Primer: Primer, when required, shall be a quick-drying, colorless, nonstaining sealer of type and consistency as recommended by the manufacturer of the sealant for the particular type of surfaces to be sealed.

C. Sealant Backing: Sealant backup or packing (backer rod) shall be a non-absorbent premolded or preformed nonstaining resilient material, such as polyethylene foam rod, or neoprene, butyl, polyurethane, or other closed cell foams or extruded rod, compatible with the sealant used. Follow sealant manufacturer’s recommendations for compatibility of backer rod with sealant used. Material shall act as a bond breaker and shall be circular in cross section.

D. Bond Breaker: When required, pressure-sensitive polyethylene tape, Teflon tape, or other plastic tape as recommended by the sealant manufacturer for the location, to prevent bond of sealant in heel of joint.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Examine substrate surfaces and joints to be sealed, and conditions under which work is to be performed, and correct conditions detrimental to proper and timely completion of the work. Do not proceed until unsatisfactory conditions have been corrected.

3.02 SURFACE PREPARATION

A. Joints and spaces to be sealed or caulked shall be cleaned of dirt, dust, mortar, oil, and other deleterious substances that may impair bond or adversely affect the sealing or caulking work. Where necessary, degrease with an approved solvent or commercial degreasing agent. Surfaces shall be dry before application of sealants or caulking compounds.

B. Do not apply sealants to joint surfaces previously treated with sealer, curing compound, water repellent, or other coatings, unless a laboratory durability test of bond cohesion has been performed successfully demonstrating that bond will be durable. Test method shall comply with procedures of the ASTM or FS applicable to the particular sealant.

C. Do not apply paint and other coatings to surfaces adjoining joints until sealants have been installed and are nominally cured.

D. If recommended by the manufacturer, remove paint and other coatings from surfaces to be sealed prior to sealant application. Remove coatings on metallic surfaces with a solvent that leaves no residue.

E. Joints shall be cleaned out, full width and depth. Joints shall be raked to proper depth, permitting use of sealant backing and sealant of indicated depth. Depth of joint in back of sealant shall be filled with sealant backing as specified. Sealant shall not be applied without sealant backing material, unless indicated otherwise on the Contract Drawings.

F. Joints shall be enclosed on three sides. Where grooves for adequate sealing have not been provided, suitable grooves shall be cleaned out to depth required or as indicated and cut or ground to minimum width of 1/4 inch without damage to adjoining work. Minor variations in width shall not require correction. Damaged adjacent or connecting work resulting from cutting or grinding shall be restored.

3.03 INSTALLATION/APPLICATION

A. Surface preparation of joints, application of primers, installation of sealant backing and bond breaker, and installation of sealant shall be in accordance with the sealant manufacturers' installation instructions and recommendations and the requirements of ASTM C1193, as applicable.

B. Thickness of sealant shall be one-half the joint width, with a minimum thickness of 1/4 inch. Sealant shall bond the two opposing surfaces of the joint.

C. Seal joints continuously with sealant around openings in exterior walls, at control and expansion joints, and at other locations indicated or required for waterproofing the building or structure. Seal and caulk joints as indicated and as required to complete the building or structure, both exterior and interior.

D. Joints shall be filled to within specified depth from the surface with sealant backing, and the remainder of joint shall then be filled with sealant as specified. Sealant shall be forced into joints mechanically, with sufficient pressure to expel all air and provide a solid filling against the sides of joint and the sealant backing or bond breaker material.

E. Sealant shall be placed before painting operations are started. Sealant in joints adjacent to painted work shall be placed before final coat of paint is applied.

F. Sealant shall be applied when ambient temperature is between 45 degrees and 90 degrees Fahrenheit and when weather conditions are favorable for sealing operations.

G. Joints receiving sealant shall have sealant backing material with diameter greater than joint width, solidly placed and properly aligned, permitting pressure-applied sealant to be of uniform thickness, positively stopped, and assuring that sealant presses firmly against joint edges for adequate bonding.

H. Concrete, masonry, stucco, and other surfaces, if recommended by the sealant manufacturer, shall be primed before applying sealant. Primer shall be applied with a brush that will reach all parts of joints to be filled with sealant.

I. Sealant in joints shall be tooled flat or slightly concave. Joints in back of applied trim shall be caulked and inspected before trim is permanently installed. Sealed and caulked joints shall be neatly pointed on flush surfaces with beading tool, and internal corners with eaving tool. Excess material shall be cleanly removed.

J. Finished sealed and caulked surfaces shall be uniformly smooth and free from wrinkles and air holes.

K. Double sealant joint shall be provided where water intrusion flashing, and barriers are not present. On the face of exterior wall, for protrusions of 4 inches or more, provide double sealant joint on all horizontal surface.

3.04 CURING AND PROTECTION

A. Cure compounds and sealants in accordance with manufacturer's instructions to obtain maximum bond to surfaces, and cohesive strength and durability at earliest possible date.

B. Provide for protection of sealants and caulking compounds during remainder of construction period, so that they will be without deterioration or damage at time of acceptance of the work.

3.05 FIELD QUALITY CONTROL

A. Perform inspections necessary to assure proper preparation of locations and joints to receive sealants and caulking and to assure compliance with manufacturer's instructions for mixing, installation, curing, and protection.

B. After curing of exterior joints exposed to weather, test for leaks by applying a stream of water perpendicular to the surface from a 1/2-inch or 5/8-inch hose at normal city water pressure. Test at least ten percent of the exposed joint system.

C. Repair leaks and retest as directed.

3.06 CLEANING

A. Confine compounds to joint areas indicated by use of masking tapes or other precautions to prevent spillage or migration onto adjoining surfaces. Remove excess compound or sealant promptly as work progresses and clean adjoining surfaces to eliminate evidence of spillage.

END OF SECTION 07 90 00

SECTION 07 95 00

EXPANSION CONTROL

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Expansion joint assemblies.

B. Fire-rated joint cover assemblies.

1.02 RELATED SECTIONS

A. Expansion and isolation joint fillers and sealants for concrete slabs and paving are specified in Section 03 15 00, Concrete Accessories.

B. Control joints for unit masonry are specified in Section 04 22 00, Concrete Unit Masonry.

C. Expansion joints in roofing are specified in the individual roofing sections under Division 7, Thermal and Moisture Protection, as applicable.

D. Sealants for sealing of perimeter joints at openings in walls and for joints at abutting materials are specified in Section 07 90 00, Joint Protection.

E. Control and expansion joints for portland cement plaster are specified in Section 09 24 11, Portland Cement Plaster.

1.03 MEASUREMENT AND PAYMENT

A. Measurement: Expansion control devices will be measured for payment by the lump-sum method, acceptably fabricated and installed.

B. Payment: Expansion control devices will be paid for at the indicated Contract lump-sum price as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM A240/A240M Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and General Applications

2. ASTM A480/A480M Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip

3. ASTM B221 — Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
4. ASTM C509 — Standard Specification for Elastomeric Cellular Preformed Gasket and Sealing Material
5. ASTM C834 — Standard Specification for Latex Sealants
6. ASTM C864 — Standard Specification for Dense Elastomeric Compression Seal Gaskets, Setting Blocks, and Spacers
7. ASTM C920 — Standard Specification for Elastomeric Joint Sealants
8. ASTM C1311 — Standard Specification for Solvent Release Sealants
9. ASTM D2240 — Standard Test Method for Rubber Property – Durometer Hardness
10. ASTM D412 — Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers – Tension
11. ASTM E119 — Standard Test Methods for Fire Tests of Building Construction and Materials
12. ASTM E814 — Standard Test Method for Fire Tests of Penetration Firestop Systems
13. ASTM F593 — Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs

B. Underwriters Laboratories Inc. (UL):

1. UL Building Materials Directory
2. UL Fire Resistance Directory

C. Warnock Hersey (WH):

1. Certification and Listings Directory

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Product Data and Shop Drawings: Submit manufacturers' product data of vertical and horizontal expansion-joint closures, assemblies, seals, and sealants for review. Include installation details.

C. Applicator's Approval: Submit document stating approved applicator that has been trained by the manufacturer and submit sample of past project accomplished.

D. Fire Rating Certification: Submit copies of UL Classification or Warnock Hersey Listing for fire-rated joint covers.

PART 2 – PRODUCTS

2.01 EXPANSION JOINT ASSEMBLIES

A. Expansion joint closures and seals shall be aluminum extrusions and neoprene or silicone rubber seals of type and size to suit the construction as indicated. Proper sizing of the expansion joint seal system shall be the Contractor's responsibility. Joint openings shall be field verified. Expansion joint shall be waterproof and leak resistant.

B. Materials and requirements include the following:

1. Aluminum Retainers and Cover Plates: Aluminum alloy meeting requirements of ASTM B221, alloy 6063-T5, anodized, of configuration and size as indicated or recommend by the expansion-control system manufacturer.

2. Visual Seals: Dense neoprene or dense silicone synthetic rubber conforming with ASTM C864, of 70 durometer hardness, plus or minus five.

3. Functional Seal: Closed cell neoprene synthetic rubber conforming with ASTM C509, medium density.

4. Corner Angles: Stainless steel conforming to ASTM A240/A240M and ASTM A480/A480M, Type 304 or 316.

5. Fasteners: Stainless steel conforming to ASTM F593 or equivalent, Type 316 or equivalent 300 Series (18-8) stainless steel.

6. Sealant: Sealant for installation behind aluminum retainer, in rear pocket of aluminum retainer, and at joints, where indicated, shall conform to ASTM C834, C920, or C1311 as appropriate for the construction and exposure conditions.

2.02 FIRE-RATED JOINT COVER ASSEMBLIES

A. Requirements: Fire-rated joint covers shall have been tested in accordance with ASTM E119 and ASTM E814, including hose stream test at full rated period. Covers shall be classified by Underwriters Laboratories or listed by Warnock Hersey, or equal. Minimum fire rating shall be two hours, but not less than rating of adjacent construction. Materials shall be inorganic and shall not create smoke or contribute fuel during a fire.

1. All metal components and cover plates shall be 300 Series (18-8) stainless steel with No. 4 finish. Aluminum is not acceptable.

B. Fire Barrier: Fabricated of layers of ceramic fiber insulation and metallic insulation.

C. Flame Sealant: Sealant shall remain resilient to permit joint movement and shall, upon exposure to heat, increase in volume to resist penetration of fire through voids in construction.

D. Fireproofing: Of type required by fire rating; asbestos is not acceptable.

E. Fire-Rated Joint Covers: Fire barrier and flame sealant shall provide required fire rating.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Expansion Joint Assemblies: Install expansion-joint assemblies and engineered floor and wall seals as indicated and in accordance with the approved Shop Drawings and the manufacturer's installation instructions and recommendations.

B. Fire-Rated Joint Assemblies: Install as required to meet fire-rated design and construction. Install fire barriers and flame sealant as required to complete the installation and meet fire-rating requirements.

C. Waterproof rubber: Installation of expansion joint with waterproof device in area where water intrusion detected, shall conform to ASTM D2240 and D412.

END OF SECTION 07 95 00

SECTION 08 01 57

WINDOW RESTORATION AND REPLACEMENT

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Windows.

B. Glass and glazing.

C. Sealants.

D. Electrolytic bituminous isolation coating.

E. Anchorage devices and fasteners.

1.02 RELATED DOCUMENTS

A. Aluminum windows are specified in Section 08 51 16, Aluminum Windows.

B. Glass and glazing are specified in Section 08 80 00, Glazing.

C. The station or building involved in this work will be in continuous operation during the construction period. This will require that the Contractor plan the work carefully to work around unavoidable obstacles. It will require further that the Contractor complete some new construction facilities required in the renovation work before proceeding with the window restoration and replacement work.

D. Provide such additional temporary facilities as may be required to facilitate continuous, unobstructed station or building operation during transitional construction work.

1.03 MEASUREMENT AND PAYMENT

A. General: Restoration and replacement of existing windows will not be measured separately for payment, but will be paid for as part of the Contract lump-sum price for Architectural Work.

1.04 REFERENCES

A. Comply with the Referenced Standards specified in Section 08 51 16, Aluminum Windows, and Section 08 80 00, Glazing, as applicable to the window restoration and replacement work.

B. American Architectural Manufacturers Association (AAMA):

1. AMAA 2604 Voluntary Specification, Performance Requirements and Test Procedures for High Performance Organic Coatings on Aluminum Extrusions and Panels (with Coil Coating Appendix)

1.05 REGULATORY REQUIREMENTS

A. Comply with the Regulatory Requirements specified in Section 08 51 16, Aluminum Windows, and Section 08 80 00, Glazing, as applicable to the window restoration and replacement work.

B. California Code of Regulations, Title 24, Part 6, California Energy Code

1.06 SUBMITTALS

A. Provide submittals in accordance with the requirements of Section 08 51 16, Aluminum Windows, and Section 08 80 00, Glazing, as applicable to the window restoration and replacement work, for the Engineer's review.

1.07 QUALITY ASSURANCE

A. Window restoration and replacement work shall conform with the installation instructions and recommendations of the manufacturer of the windows to be provided for this work.

B. Quality assurance for the window restoration and replacement work shall conform with the quality assurance requirements of Section 08 51 16, Aluminum Windows, and Section 08 80 00, Glazing, as applicable.

1.08 WARRANTY

A. Comply with the warranty requirements of Section 08 51 16, Aluminum Windows.

PART 2 – PRODUCTS

2.01 MATERIALS, EQUIPMENT, AND FACILITIES

A. Requirements: Provide all materials, equipment, tools, appurtenances, facilities, and services as required for performing and completing the window restoration and replacement work as indicated.

B. Windows:

1. Windows shall be monumental, operable and fixed sash aluminum windows, as indicated, conforming with applicable requirements of Section 08 51 16, Aluminum Windows.

2. Windows shall be fully glazed insulated-glass units, as indicated, furnished complete with continuous moldings and glazing stops, frames, finish window hardware, and all anchors, fasteners, and accessories as required for a complete and finished, operable installation.

3. Finish for windows shall be a full 70 percent polyvinyldene fluoride finish conforming with requirements of AAMA 2604. Color: as selected by the Engineer from manufacturer's standards.

4. Window units and operable vents shall be fully weatherstripped in accordance with the manufacturer's standards.

C. Glass and Glazing: Factory glaze sash with clear float, insulating glass as specified in Section 08 80 00, Glazing. Units shall be "wet" glazed" with snap-in aluminum extruded glazing bead and PVC bulb on the interior of the glass. Exterior glass shall be set in a continuous bead of silicone sealant. Provide for expansion and contraction of acoustical glass.

D. Sealants: Refer to Section 07 90 00, Joint Protection, for requirements.

E. Electrolytic Bituminous Isolation Coating: Asphalt- or coal-tar pitch-based paint or varnish of heavy or thick consistency, or 1/16-inch thick neoprene or butyl tape.

F. Anchorage Devices and Fasteners: Tempered aluminum or 30 Series stainless steel when exposed; cadmium- or zinc-plated when concealed.

PART 3 – EXECUTION

3.01 EXAMINATION AND PREPARATION

A. After careful removal of existing windows, examine existing framed window openings for damaged and defective framing. Damaged or defective framing shall be repaired or replaced as required to provide substantial framed substrate surfaces conducive to the installation of new windows and related flashings.

B. Where aluminum is installed in contact with dissimilar metals, concrete, masonry, or stucco, the aluminum shall be painted with bituminous isolation coating or separated with neoprene or butyl tape.

C. Aluminum surfaces to be in contact with sealants shall be cleaned with solvent.

3.02 INSTALLATION OF NEW WINDOWS

A. New windows shall be installed in accordance with Section 08 51 16, Aluminum Windows, as applicable to the work of this Section.

B. All work shall be performed and completed as required to obtain the required warranties specified in Section 08 51 16, Aluminum Windows.

3.03 REHABILITATION OF EXISTING WINDOWS

A. Rehabilitate existing windows to like new condition. Operable vents shall operate smoothly and effortlessly under normal opening and closing pressures. Lubricate as required. Operable vents shall be watertight in closed position.

B. Cracked and broken glass shall be replaced, and shall conform with applicable requirements of CCR Title 24, Part 6, California Energy Code.

C. Repainting of existing windows shall conform with applicable requirements of Section 09 91 00, Painting. Color and sheen shall be as selected by the Engineer.

3.04 ADJUSTING

A. Comply with the adjusting requirements of Section 08 51 16, Aluminum Windows.

3.05 CLEANING

A. Comply with the cleaning requirements of Section 08 51 16, Aluminum Windows, and Section 08 80 00, Glazing.

END OF SECTION 08 01 57

SECTION 08 11 00

METAL DOORS AND FRAMES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Metal doors.

B. Lights and vision panels.

C. Louvers.

D. Fire-rated doors.

E. Acoustical doors.

F. Metal frames.

G. Door seals and weatherstripping.

H. Door silencers.

1.02 MEASUREMENT AND PAYMENT

A. General: Steel Doors and Frames will not be measured separately for payment but will be paid for as part of the Contract lump sum price for Architectural Work.

1.03 REFERENCES

A. American National Standards Institute (ANSI):

1. ANSI/ SDI A250.10 — Standard Test Procedure and Acceptance Criteria for Prime Painted Steel Surfaces for Steel Doors and Frames

B. American Society for Testing and Materials (ASTM):

1. ASTM E90 — Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements

C. National Fire Protection Association (NFPA):

1. NFPA 80 — Standard for Fire Doors and Other Opening Protectives

2. NFPA 252 — Standard Methods of Fire Tests of Door Assemblies

D. Steel Door Institute (SDI):

1. SDI A250.8 Recommended Specifications for Standard Steel Doors and Frames
2. SDI A250.11 Recommended Erection Instructions for Steel Frames
3. SDI A250.6 Recommended Practice for Hardware Reinforcing on Standard Steel Doors and Frames
4. SDI 110 Standard Steel Doors and Frames for Modular Masonry Construction
5. SDI 111 Recommended Selection and Usage Guide for Standard Steel Doors, Frames and Accessories
6. SDI 128 Guidelines for Acoustical Performance of Standard Steel Doors and Frames
7. SDI 117 Manufacturing Tolerances for Standard Steel Doors and Frames
8. SDI 118 Basic Fire Door Requirements
9. SDI 131 Accelerated Physical Endurance Test Procedure for Steel Doors, Frames, and Frame Anchors

E. Underwriters Laboratories (UL):

1. UL 10B UL Standard for Safety Fire Tests of Door Assemblies

F. Warnock Hersey (WH)

1.04 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit Shop Drawings for hollow metal doors and frames showing size, location, and elevation of each metal door and frame, gage and type of material, details for fabrication of each door and frame, including size and location of each mortise, penetration, reinforcement, sound seal, light, louver, and anchoring device. Indicate the quantity of each size and type of door and frame. Comply with applicable requirements of SDI A250.8 and SDI 111 Series Drawings.

C. Product Data: Submit manufacturer’s product data of each type of door and frame and certification that materials meet Specification requirements.

D. Reports and Certificates:

1. Submit certified test reports from an independent testing laboratory of sound transmission class (STC) ratings for acoustical door assemblies.

2. Submit certificates of inspection as required for fire-rated doors.

1.05 QUALITY ASSURANCE

A. Manufacturing Standards: Comply with applicable requirements of SDI A250.8.

B. Manufacturing Tolerances: Comply with applicable requirements of SDI 117.

C. Fire-Rated Doors and Frames: Comply with applicable requirements of SDI A250.8 and SDI 118.

D. Acoustical Doors and Frames: Comply applicable requirements of SDI A250.8. Sound transmission class (STC) ratings shall be based on door-and-frame assemblies tested in accordance with ASTM E90.

PART 2 – PRODUCTS

2.01 DOORS

A. Classification: Level and model shall conform with SDI A250.8 as follows:

1. Doors in Public Areas: Level 3 Extra Heavy Duty, Model 2, Seamless, hollow steel construction, internally reinforced with minimum 22 gage continuous vertical formed stainless steel sections spanning the full thickness of the interior space between door faces, securely attached to face sheets by spot welds spaced maximum five-inches on center. Minimum face gage shall be 16-gage. Spaces between internal stiffeners shall be filled to full height of door with chemically inert, noncombustible moisture-resistant mineral fiber. Sizes and thicknesses as indicated. Doors shall be fabricated from Type 304 stainless steel. Surfaces exposed to view shall be polished to a Number 4 satin finish.

2. Doors for District Personnel Use Only in Tunnels: Level 2 Heavy-Duty, Model 1 or 2, full flush type, hollow steel or composite construction, of sizes and thicknesses indicated. Doors shall be fabricated from Type 304 stainless steel and painted.

3. Doors for District Personnel Use Only not in Tunnels or Public Areas: Level 3 Extra Heavy Duty, Model 2, Seamless, hollow steel construction, internally reinforced with minimum 22 gage continuous vertical formed steel sections spanning the full thickness of the interior space between door faces, securely attached to face sheets by spot welds spaced maximum five-inches on center. Minimum face gage shall be 16-gage. Spaces between internal stiffeners shall be filled to full height of door with chemically inert, noncombustible moisture-resistant mineral fiber. Sizes and thicknesses as indicated.

B. Doors shall be prepared and reinforced for installation of hardware in accordance with SDI A250.6.

C. Lights and Vision Panels: Comply with glazing requirements of SDI A250.8. Provide for glazing with synthetic rubber gaskets. Coordinate with Section 08 80 00, Glazing. Glass shall not contact metal.

D. Louvers: Comply with louvered-door requirements of SDI A250.8 and SDI 111. Provide Inverted "V" Blade, "Z" Blade, or Inverted "Y" Blade inserted louvers as indicated, complete with frame and moldings. For exterior doors, provide "Z" Blade or Inverted "Y" Blade louvers. For fire-rated doors, provide Fusible Link louvers in accordance with requirements of SDI 111 and SDI 118. Louvers shall be a minimum of 16 gage cold rolled steel. All louvers shall be vandal proof with pinned stainless steel flat head security screws and single sided mounting for stainless steel doors. Provide stainless steel louvers for stainless steel doors.

E. Fire-Rated Doors: Where indicated to be fire doors (fire-rated), or where class of opening requires fire door, provide fire doors and frames in accordance with requirements of SDI A250.8 and SDI 118, of full flush type (Model 1 or 2). Provide each door with label of Underwriters Laboratories Inc. (UL) or Warnock Hersey (WH) for class of opening as indicated in accordance with SDI 118. Labels shall be metal, fastened to hinge stile edge of door.

F. Acoustical Doors: Provide acoustical doors where indicated of full flush type in accordance with SDI A250.8. Provide door and frame assembly with sound transmission class (STC) rating as indicated when tested in accordance with SDI 128. Door and frame units shall be complete with necessary seals and rubber gasketing to achieve the rating.

2.02 FRAMES

A. Frames shall be hollow pressed-steel frames, combination buck, frame, and trim type as indicated, welded frames, conforming to SDI A250.8. Corners shall be mitered, fully welded, and ground smooth. Integral stops (rabbets) shall be not less than 5/8 inch in depth.

B. Frames shall be prepared and reinforced for installation of hardware in accordance with SDI A250.6. Steel for frames shall be not lighter than 16 gage. For openings wider than six feet, provide 14 gage steel.

C. Frames for openings in masonry walls shall conform with applicable requirements of SDI 110.

D. Frames for fire-rated doors and openings shall conform with requirements of SDI A250.8 and SDI 118 for class of opening indicated. Provide each fire-rated frame with UL or WH label for class of opening, or submit proof of conformance with UL or WH labeling requirements for approval.

E. Frames for stainless steel doors shall be stainless steel having same finish as doors.

2.03 SHOP FINISH

A. Doors and frames shall be treated for paint adherence and given a baked-on corrosion-inhibitive prime coat of metallic oxide or synthetic resin primer in accordance with SDI A250.8 and meeting acceptance criteria of ANSI/SDI A250.10.

B. Finish field painting is specified in Section 09 91 00, Painting.

2.04 DOOR SEALS AND WEATHERSTRIPPING

A. Doors and frames shall be fitted with door seals or gaskets where indicated, and exterior doors and frames shall be fitted with applied rain drips and weatherstripping on all four sides (entire perimeter of opening) in accordance with applicable requirements of SDI 111.

B. Weatherstripping and seals shall be non-ferrous, with synthetic rubber edge seals where indicated or required, of type or style appropriate for the purpose. Drips and visible weatherstripping shall be painted out to match doors and frames.

C. Door seals or gasketing for fire-rated doors and acoustical doors shall be synthetic rubber of type manufactured and appropriate for the purpose.

D. Coordinate types and scheduling of door seals and weatherstripping with Contract Specifications 08 71 00, Door Hardware, and the types of thresholds to be furnished.

2.05 DOOR SILENCERS

A. Provide pneumatic rubber silencers for interior doors, except fire-rated doors. Coordinate with Section 08 71 00, Door Hardware. Provide as follows:

1. Single-Leaf Doors: Three each lock jamb frame.

2. Double-Leaf Doors: Two each leaf at head frame, plus three each on astragal.

B. Silencers shall be installed in stops of frames.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Installation Standards: Install door frames and doors in accordance with SDI A250.8, meeting the performance and acceptance criteria of SDI 131. Door frames and doors installed in masonry walls shall meet the requirements of SDI A250.8 and SDI 110.

B. Frames: Frames shall be set accurately in position, plumbed, aligned, and braced securely until permanent anchors are installed. Where frames require ceiling struts or other structural overhead bracing, they shall be anchored securely to structure above, as required. Where indicated or required by class of opening, frames shall be filled solid with portland cement grout by providing one inch grout holes at top of each door jamb. Provide additional grout holes as required to fill around internal obstructions.

C. Doors: Doors shall be hung by skilled workers to fit snug against stops. Fit accurately and hang free from hinge bind with uniform clearance of 3/32 inch at heads and jambs. After hanging, make adjustments, and then remove doors and hardware for finish painting and make final adjustments. Verify that direction of swing is as indicated.

D. Finish Hardware: Coordinate installation with Contract Specifications Section 08 71 00, Door Hardware.

1. Install accurately and securely without marking or defacing hardware or finish work. Hardware shall be fastened with machine screws or bolts. Sheet metal screws will not be permitted. Test hardware to assure correct alignment and operation. Finish hardware shall be fastened at all points where fasteners are indicated or required.

2. Thresholds shall be embedded in approved sealant, and shall be secured to concrete floors with stainless steel screws in nonferrous expansion shields.

3. Provide hardware in satisfactory working order. Clean and polish.

E. Door Seals and Weatherstripping: Weatherstripping and seals shall be installed to provide rainproof service and so that there is no air, light, and sound leakage. Stops shall fit tight against doors.

F. Fire-Rated Doors and Frames: Installation of doors and frames, including hardware and operational characteristics, shall be in accordance with NFPA Standard No. 80, as applicable. Verify that doors and frames are labeled as indicated.

G. Prime Paint Touch-Up: Immediately after installation, touch up damaged prime coat with the same primer as was used for the shop finish. Lightly sand and feather out damaged surfaces so that paint touch-up becomes invisible. Spray paint touch-up work.

H. Temporary Protection: Provide protective facings or coverings for doors and frames to receive continued use during construction.

I. Access Control: Coordinate installation with Contract Specifications Section 28 10 01, Access Control System, at door and frame where occurs.

J. Prepare door frames including pre-drilling cutouts and holes as necessary to facilitate and integrate door access control installation.

END OF SECTION 08 11 00

SECTION 08 31 00

ACCESS DOORS AND PANELS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Access doors for concrete and masonry construction.

B. Access doors for plaster construction.

C. Access doors for gypsum board construction.

D. Access doors for ceramic tile surfaces.

E. Access doors for floors.

F. Access hatches at station platforms.

G. Access hatch smoke vent.

1.02 RELATED SECTIONS

A. Section 03 30 00, Cast-In-Place Concrete.

1.03 MEASUREMENT AND PAYMENT

A. General: Separate measurement or payment will not be made for the work required under this Section. All costs in connection with the Work specified herein will be considered to be included or incidental to the Work of this Contract.

1.04 DESCRIPTION

A. Furnishing and installing access doors and hatches in finished surfaces to provide access to mechanical, electrical, and piping control devices concealed behind finished surfaces as indicated and required.

B. Concealed work, to which access must be available to personnel after completion, shall have appropriate access doors and frames as specified herein furnished and installed by the Contractor.

C. Locations shall be suitable for access required and shall be approved by the Engineer before installation. Access panels shall be compatible with the construction in which they are installed, and installation shall be complete with required hardware, grounds, screeds, attachment devices, and trim.

D. Coordinate with the Facility Services Section requirements.

1.05 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM A123 Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

2. ASTM A167 Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip

B. National Association of Architectural Metal Manufacturers (NAAMM):

1. NAAMM AMP503 Finishes for Stainless Steel

C. Underwriters Laboratories Inc. (UL):

1. UL Building Materials Directory

1.06 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirement and procedures.

B. Shop Drawings and Product Data: Submit Shop Drawings and manufacturer's product data of each different type of access door and panel proposed to be furnished, including the locations of each. Include installation details appropriate for the type of construction into those doors and panels will be installed.

1.07 QUALITY ASSURANCE

A. Regulatory Requirements: Where access is required in one-hour or two-hour fire-rated walls or partitions, floors or ceilings, provide access door assembly of type and manufacture listed in the UL Building Materials Directory. Provide UL or equivalent label on each fire-rated access door assembly.

B. Templates and Setting Instructions: Provide complete information, diagrams, templates, and installation instructions as required for access doors and panels provided herein, and in sufficient time so that backing and framing can be properly installed, and so that work of other trades will not be delayed.

PART 2 – PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Provide access door or panel as a single integral unit with frame, anchors, hardware, accessory parts, fittings and fastenings. Units shall be the standard products of the manufacturer, modified as necessary to meet requirements.

B. Where size of door or panel is not indicated, furnish 24 inches by 24 inches size for hand access or 36 inches by 36 inches size where body access is necessary.

2.02 ACCESS DOORS FOR CONCRETE AND MASONRY CONSTRUCTION

A. Door: Full flush design of 16 gage mild steel, double pan, fully welded, encapsulating two inches of rigid insulation.

B. Frame: 14 gage mild steel with joints fully welded and ground smooth.

C. Anchors: Corrugated steel or similar steel anchors for concrete and masonry construction, galvanized.

D. Hinge: Continuous with stainless steel pin that permits opening door to 175 degrees.

E. Closer: Spring, torque, or tension.

F. Lock: Flush, key-operated to accept District's designated CAT 74 key, spring-loaded latch and interior release.

G. Finish: Phosphate-treated and prime painted, manufacturer's standard.

H. Fire-Rating Label: UL 1-1/2 hour "B" label.

2.03 ACCESS DOORS FOR PLASTER CONSTRUCTION

A. Door: Full flush design of 18 gage mild steel, double pan, fully welded, encapsulating two inches of rigid insulation.

B. Frame: 16 gage fully welded mild steel with a one-inch deep plaster ground on three inches wide expanded metal lath.

C. Anchors: No. 10-32 FHMS to steel studs at 12 inches on center.

D. Hinge: Continuous with stainless steel pin which permits opening door to 175 degrees.

E. Closer: Spring, torque, or tension.

F. Lock: Flush, key-operated to accept District's designated CAT 74 key, spring-loaded latch and interior release.

G. Finish: Phosphate-treated and prime painted, manufacturer's standard.

H. Fire-Rating Label: UL 1-1/2 hour "B" label.

2.04 ACCESS DOORS FOR GYPSUM BOARD CONSTRUCTION

A. Door: Single sheet of 14 gage galvanized mild steel sheet.

B. Frame: 16 gage galvanized mild steel with drywall bead.

C. Anchors: Self-drilling, self-tapping screws to steel studs at eight inches on center.

D. Hinges: Concealed spring-loaded that permits opening door to 175 degrees.

E. Lock: Flush, key-operated to accept District's designated CAT 74 key, spring-loaded latch and interior release.

F. Finish: Phosphate-treated and prime painted, manufacturer's standard.

2.05 ACCESS DOORS FOR CERAMIC TILE SURFACES

A. Door: Single sheet of 14 or 16 gage, Type 304 stainless steel sheet meeting requirements of ASTM A167.

B. Frame: 16 gage stainless steel with fully welded joints ground smooth.

C. Anchors: Self-drilling, self-tapping screws to steel studs at eight inches on center.

D. Hinges: Concealed spring-loaded that permits opening door to 175 degrees.

E. Lock: Flush, key-operated to accept District's designated CAT 74 key, spring-loaded latch and interior release.

F. Finish: Satin (NAAMM AMP 503 No. 4 finish).

2.06 ACCESS DOORS FOR FLOORS

A. Door: Diamond or checkered pattern, one-fourth inch thick steel plate minimum, designed for live load of 300 pounds per square foot.

B. Frame: Integral gutter-frame of one-fourth inch steel plate with a continuous anchor flange. Equip gutter with one-and-one-half inch coupling for drainage connection.

C. Hinges: Heavy forged brass with stainless steel pins.

D. Control: Coil spring opening assist and closing retarder. Provide hold open arm that becomes engaged when the door reaches its fully open position. Provide hold open release handle.

E. Lock: Spring-loaded stainless steel latch with interior handle and removable exterior wrench. Provide two interior slide bolts on inactive leaf of pair of doors.

F. Finish: Galvanized after fabrication in accordance with ASTM A123.

G. Safety Chain: Provide safety chain on inactive side of pair of open doors.

2.07 ACCESS HATCHES AT STATION PLATFORMS

A. Pan Type Door: Fabricated from minimum 3/16-inch thick Type 304 or Type 316 stainless steel plate with stainless steel angle frame meeting requirements of ASTM A167, designed for live load of 300 pounds per square foot.

B. Frame: Type 304 or Type 316 stainless steel angle frame anchored in concrete.

C. Hinges: Heavy forged brass with stainless steel pins.

D. Control: Coil spring opening assist and closing retarder. Provide hold open arm that becomes engaged when the door reaches its fully open position. Provide hold open release handle.

E. Lock: Spring-loaded stainless steel latch with interior handle and removable exterior wrench. Provide two interior slide bolts on inactive leaf of pair of doors. Lock to be operable from below at all times.

F. Finish: At top edges of frame and pan, provide NAAMM AMP 503, No. 4 finish.

G. Epoxy adhesive: Refer to Section 03 30 00, Cast-in-Place Concrete, for requirements.

H. Safety Chain: Provide safety chain on inactive side of pair of open doors.

2.08 ACCESS HATCH SMOKE VENT

A. Single Leaf Door: Provide door fabricated from minimum 14 gage hot-dip galvanized steel cover, complete with one-inch insulation protected by metal liner, neoprene draft seal, and inside handle.

B. Curb: Provide metal curb fabricated from 14 gage hot-dip galvanized steel, complete with counterflashing and one-inch insulation outside. Curb shall be 12 inches high, formed with three-and-one-half inch roof flange anchored in concrete.

C. Hardware: Provide smoke vent equipped with spring hinges, hydraulic shock absorbers, shubber springs, and spring latch with Underwriters Laboratories approved 160-degree Fahrenheit fusible link. All hardware shall be zinc-plated.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Access doors and panels shall be installed as indicated and in accordance with the approved Shop Drawings and the manufacturer's installation instructions and recommendations. Finished installations shall be square and true, plumb and level, as required, and flush with surrounding surfaces. In tile walls, align edges with tile joints.

B. Coordinate the locations of access doors and panels with the Engineer and receive approval from the Engineer for exact locations before doing any installation work. Coordinate the installation of access doors and panels with the trades in whose finishes the doors and panels will be installed. See that appropriate finish materials are installed in recesses of door panels as required to match surrounding adjacent surfaces.

C. Access doors and panels required for plumbing, mechanical, and electrical equipment and items requiring access, in other Sections when applicable, shall be installed under this Section in accordance with the approved Shop Drawings, and the manufacturer's installation instructions and recommendations, and as required to complete the work.

END OF SECTION 08 31 00

SECTION 08 31 19

SUBWAY CROSS-PASSAGE DOORS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Doors.

B. Track.

C. Load bar.

D. Wheels.

E. Door binders.

F. Counterweigh closure system.

G. Continuous head guide.

H. Pulls.

I. Bent plate.

J. Finish.

K. Miscellaneous.

1.02 RELATED SECTIONS

A. Section 09 91 00, Painting

1.03 MEASUREMENT AND PAYMENT

A. General: Separate measurement or payment will not be made for the work required under this Section. All costs in connection with the Work specified herein will be considered to be included or incidental to the Work of this Contract.

1.04 REFERENCE STANDARDS

A. ASTM International (ASTM):

1. ASTM A366 Specification for Steel, Carbon, Cold-Rolled Sheet, Commercial Quality

2. ASTM E152 Method for Fire Tests of Door Assemblies

B. California Code of Regulations:

1. Title 24, Part 2, California Building Code, Chapter 10, Section 1004 - Doors

C. National Fire Protection Association (NFPA):

1. NFPA 80 Fire Doors and Windows
2. NFPA 130 Standard for Fixed Guideway Transit and Passenger Rail Systems

D. Steel Door Institute (SDI):

1. ANSI/SDI-100 Recommended Specifications for Standard Steel Doors and Frames
2. SDI-107 Hardware on Steel Doors (Reinforcement--Application)
3. SDI-111 Recommended Standard Details, Steel Doors and Frames
4. SDI-112 Galvanized Standard Steel Doors and Frames
5. SDI-117 Manufacturing Tolerances, Standard Steel Doors and Frames
6. SDI-118 Basic Fire Door Requirements
7. ANSI/SDI A123.1 Nomenclature for Steel Doors and Steel Door Frames

1.05 SUBMITTALS

A. Refer to Contract Specifications Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Product Data: Submit manufacturer’s product data for components.

C. Shop Drawings: Submit fully detailed Shop Drawings and installation drawings.

D. Engineering Calculations: Submit cyclic load calculations.

1.06 CLOSEOUT SUBMITTALS

A. Record Documents: Include the installed counter weight at each door and the tested opening pressure when fully adjusted.

1.07 QUALITY ASSURANCE

A. Manufacturing Standards: Comply with applicable requirements of ANSI/SDI-100.

B. Manufacturing Tolerances: Comply with applicable requirements of SDI-117.

C. Doors and Associated Hardware: Provide doors and hardware approved by the BART System Safety Department for a fire resistance rating of 1-1/2 hours. Comply with applicable requirements of ANSI/SDI-118. Classification shall be based on door-and-frame assemblies tested in accordance with ASTM E152.

D. Doors: Provide self-closing doors equipped with pull handles to allow opening from either side. The force required to open the door fully shall be in accordance with NFPA 130 and California Building Code, Section 1004, Doors.

PART 2 – PRODUCTS

2.01 CROSS-PASSAGE DOORS

A. Doors:

1. Cross-passage doors shall be full flush design, with sealed tops, galvanized steel faced, solid core fire doors, 1-3/4 inches thick, with face sheets of ASTM A366 cold-rolled, pickled and oiled, minimum 14 gage steel. Doors shall be reinforced with formed 1/8 inch steel channels extending full height of door. Reinforced channels shall be spaced approximately 4 inches on center and spot welded to the face sheets at three inches on center.

2. Faces of doors shall be flat with no joints, weld marks or bumps. Provide 1/8 inch steel channel completely around the door perimeter, welded to face at three inches on center.

3. Door construction, conforming to the requirements of Underwriters Laboratories, shall meet the required fire rating in accordance with NFPA 130. The hardware and other details need not meet these requirements.

4. Doors shall be furnished complete with all necessary hardware, including track, adjustable track brackets, load bar, hangers, trolleys, continuous head guide and stay rollers, front and rear door and wall binders, counterweight with enclosure, and all anchors for securing to the structure. All mounting hardware shall be stainless steel.

5. Door fabrication and construction shall comply with ANSI/SDI-100, SDI-107, SDI-111, SDI-112, SDI-117, SDI-118, and SDI-123.1 as applicable.

B. Track: Track shall be box type, galvanized 3/16 inch steel with a minimum capacity of 1,000 pounds. Joints in track shall be welded flush and smooth.

C. Load Bar: Heavy steel, with drop forged and heat-treated pendant. Connecting bolt shall be 1-1/4 inch heavy steel, set in an oversized hole in the load bracket. Load bar assembly shall allow for lateral and vertical adjustment.

D. Wheels: Minimum 2-1/8 inch diameter machine steel with heavy-duty ball bearings.

E. Door Binders: Front and rear door and wall binder shall be full height, and shall be incorporated for closed position. Minimum 3/16 inch separation needs to be maintained between the interlock head binder and the door guide binder.

F. Counterweight Closure System: Doors shall be equipped with a counterweight closure system with weight box and an anti-creep device. Counterweight system shall be drop forged. Weight box shall be made of galvanized steel, access to adjustments. Provide 16 gage galvanized steel plate covering counterweight.

G. Continuous Head Guide: Fabricated from 3/16 inch galvanized bent steel overlapping rough opening.

H. Pulls: Provide pulls operable from either side. Furnish a latch to keep the door in an open position.

I. Bent Plate: Minimum 3/8 inch thick, size as indicated.

J. Finish: Surfaces shall be smooth and free from warps and buckles, with tight doors and miters neatly made. Doors shall be painted using exterior Paint System B as described in Contract Specification Section 09 91 00, Painting. Graphics and colors shall be as indicated on the BART Standard Plans CS61.

K. Door and door assembly shall be designed to resist a water column of plus 14 inches to minus seven inches.

L. Miscellaneous:

1. Fusible links shall not be provided.

2. Continuous floor guides shall not be used.

3. Furnish all necessary closures, filler members, reinforcing, and appurtenant members and accessories for doors.

M. Cyclic Loads: Door and door components shall resist the maximum pressure differential for at least 10 million cycles.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Doors shall be suspended from an overhead track, surface mounted as detailed.

B. Doors: Doors shall be hung by skilled workers. Fit accurately and hang plumb. After hanging, make adjustments, and then remove doors and hardware for finish painting and make final adjustments. The doors shall be adjusted to be self-closing and yet not exceed the opening pressure requirements of NFPA 130.

C. Finish Hardware:

1. Install accurately and securely without marking or defacing hardware or finish work. Hardware shall be fastened with machine screws or bolts. Sheet metal screws will not be permitted. Test hardware to assure correct alignment and operation. Finish hardware shall be fastened at all points where fasteners are indicated or required. Stainless steel expansion bolts shall be used when anchoring to concrete.

2. Provide hardware in satisfactory working order. Clean and polish.

D. Fire-Rated Doors and Frames: Installation of doors and frames, including hardware and operational characteristics, shall be in accordance with NFPA Standard No. 80, as applicable. Verify that doors and frames are labeled as indicated.

E. Prime Paint Touch-Up: Immediately after installation, touch up damaged galvanizing with the zinc rich primer.

F. Temporary Protection: Provide protective facings or coverings for doors and frames.

END OF SECTION 08 31 19

SECTION 08 33 13

COILING COUNTER DOORS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Roll-up (coiling) counter doors.

1.02 RELATED SECTIONS

A. Section 01 33 00, Submittal Procedures.

B. Section 01 33 23, Shop Drawings, Product Data, and Samples.

C. Section 01 78 23, Operation and Maintenance Data.

1.03 MEASUREMENT AND PAYMENT

A. General: Separate measurement or payment will not be made for the work required under this Section. All costs in connection with the Work specified herein will be considered to be included or incidental to the Work of this Contract.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM A240/A240M Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings and Product Data: Submit Shop Drawings and manufacturer's product data of roll-up counter doors, including materials, finishes, details of installation, associated accessories, and locking hardware.

C. O&M Manual: Submit operation and maintenance manual in accordance with the requirements of Section 01 78 23, Operation and Maintenance Data.

1.06 QUALITY ASSURANCE

A. Provide the services of a manufacturer's representative, experienced in the installation, operation, and maintenance of overhead coiling counter doors of the type specified, for technical assistance and advice during installation and testing.

PART 2 – PRODUCTS

2.01 ROLL-UP (COILING) COUNTER DOORS

A. Type and Manufacture: Roll-up counter doors shall be complete, factory-fabricated door and frame assemblies, manufactured of 300 Series stainless steel, hand push-up or crank operated, mounted within the provided opening as indicated. Doors shall be counter-balanced for smooth and easy operation.

B. Door Components:

1. Curtain: Interlocking slats, flat slat design, manufactured from ASTM A240/A240M Series 300 stainless steel, minimum 22 gage. Size and style of slat shall be as selected by the Engineer from manufacturer's standards.

2. Guides: 300-Series stainless-steel box guides.

3. Footpiece: 300-Series stainless-steel tubular section with rubber bumper and with two recessed pulls for hand push-up operated doors.

4. Hood: Minimum 24 gage 300 Series stainless steel.

5. Weatherstripping: Wool pile at jambs for weatherproofing, dust protection, and to eliminate metal-to-metal contact.

6. Security Hardware: Concealed slide bolt operated by thumb knob from interior side only.

7. Fasteners: 300 Series stainless steel.

8. Operation: Hand push-up operation for doors up to four feet six inches in width, and hand crank operation for doors more than four feet six inches in width.

9. Gears: Cast iron, with gear ratio designed for maximum 30-pound manual effort.

10. Counterbalancing: Adjustable oil-tempered torsion springs capable of counterbalancing weight of curtain; with barrel sized to limit deflection to 0.03 inch per foot.

11. Finish: No. 4 polished satin finish for exposed stainless steel surfaces.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install roll-up (coiling) counter doors in accordance with the manufacturer’s installation instructions and the approved Shop Drawings.

B. Test, adjust, and service the door assembly as required for proper operation.

3.02 COMPLETION

A. At completion, the counter door assembly shall be square, plumb, and level, accurately aligned, and securely anchored to the supporting structure.

B. Roll-up counter doors shall operate smoothly, quietly, and free from binding, with the footpiece striking sill surface uniformly for its entire length.

C. Exposed surfaces of assembly shall be clean and free from scratches, dents, tool marks, stains, discoloration, and other defects and damage.

D. At completion, lubricate moving parts as required for a smooth and quiet operation. Clean and polish all exposed surfaces.

END OF SECTION 08 33 13

SECTION 08 33 19

OVERHEAD COILING DOORS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Roll-up (coiling) service doors.

B. Power operating equipment.

1.02 RELATED SECTIONS

A. Section 08 71 00, Door Hardware.

1.03 MEASUREMENT AND PAYMENT

A. General: Separate measurement or payment will not be made for the work required under this Section. All costs in connection with the Work specified herein will be considered to be included or incidental to the Work of this Contract.

1.04 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirement and procedures.

B. Shop Drawings and Product Data: Submit detailed Shop Drawings and manufacturer's product data of overhead coiling doors, including installation details and wiring diagrams.

C. Operation and Maintenance Data:

1. Submit operation and maintenance data in accordance with requirements of Section 01 78 23, Operation and Maintenance Data.

2. Submit recommended spare parts list, together with parts' numbers and prices, and photographs or cuts of repair parts.

3. Submit operation and maintenance manual containing printed instructions relative to operation, adjustment, care, and maintenance of the equipment. Include wiring diagrams showing field changes, if any.

1.05 QUALITY ASSURANCE

A. Provide the services of a manufacturer's representative, experienced in the installation, operation, and maintenance of overhead coiling doors of the type specified, for technical assistance and advice during installation and testing.

1.06 SPARE PARTS

A. Provide one set of critical spare parts for each door, boxed and identified, including installation instructions, wiring diagrams, and other information as necessary to make emergency repairs.

PART 2 – PRODUCTS

2.01 ROLL-UP (COILING) DOORS

A. Type and Manufacture: Roll-up (coiling) service doors shall be motor-operated, steel roll-up type, face-mounted as indicated. Doors shall be spring counter-balanced such that door rises from fully closed position to the 2/3 open position by itself if motor operator main drive chain to barrel is disconnected.

B. Design Criteria: Doors shall be designed and manufactured to be fully operable under a wind load of 20 pounds per square foot.

C. Steel Type Curtain: Consist of interlocking slats fabricated from minimum No. 20 gauge, or heavier if required by size of door or fire-rating class, hot-dipped galvanized copper bearing strip steel. Galvanizing shall be in accordance with ASTM Standards with not less than 1 1/4 ounces per square foot of slat material. Prepare for painting with phosphate treatment standard with the manufacturer. Bottom edge of curtain shall be reinforced with two angles back to back. Style of slats shall be flat and rectangular as selected by the Engineer from manufacturer's standards.

D. Rubber Type Curtain: Consist of two layers of styrene-butadiene rubber (SBR), each layer 1/8 inch thick, Shore A 60 to 70 durometer, sandwiched and reinforced with one ply of 110 lb polyester cord center. Entire door curtain and guides shall comply with ASTM D 378 flameout test time of 60 seconds or less.

E. Weather Seal: Weather seal shall be a compressible weatherseal mounted along the bottom edge of the door. Color of sealing strip shall be white.

F. Guides: Guides shall be of standard rolled steel angles or channels, as required, not less than 3/16 inch thick and of sufficient size to retain curtain in guides at a wind pressure of 20 pounds per square foot. Include all anchors, fasteners, and accessories as required to properly prepare door opening for installation of the guides.

G. Brackets: Brackets shall be of fabricated mild steel plate, bolted to wall angles that extend continuously from the floor to the top of the curtain brackets. Each wall angle shall in turn be secured to the wall with not less than five 1/2 inch standard bolts or anchors as applicable.

H. Barrel: Barrel shall house an oil-tempered helical counterbalance spring and be of sufficient size to prevent deflection of over 0.03 inch per foot of opening span. Shaft bearings in barrel and bracket shall be roller bearing thoroughly lubricated to require no further attention.

I. Hood: Hood shall be formed to fit the contour of the brackets and shall be fabricated of not less than 24 gauge galvanized steel. Hood shall be continuous one piece over the full length of overhead door except at motor. Motor hood shall be a one piece hood connected to the overhead door hood. Motor hood shall have access panels where necessary.

J. Weatherstripping: Hood shall have a hinged baffle of neoprene and galvanized sheet metal so positioned that it will form an effective draft stop when the door is in the closed position. Jambs shall be weatherstripped with continuous end lock, and shall have a continuous bronze strip with webbing.

K. Steel Curtain Finish: Finish shall consist of one factory-applied, manufacturer's standard shop coat of rust-inhibitive metal primer before shipment.

2.02 POWER OPERATING EQUIPMENT

A. Roll-up (coiling) doors shall be motor-operated with a 1 HP minimum motor operator Micanan PRO-GHC or equal equipped with a gearbox BHC-80 or equal with 1.375 inch diameter output shaft. Motor sprocket shall be No. 60, 24 tooth minimum size. Curtain speed shall be 12 to 18 inches per second. Key switch shall be constant pressure required to operate door in either direction, spring loaded to return to center "OFF" position and stop door if key is released. An "OFF" button shall not be provided. Equipment and accessories necessary for the proper operation of doors shall be provided. Motors shall be electric hoist-type, high-starting torque, providing sufficient power to operate doors at approximately one foot per second without shock.

B. Provide prewired power operator with operating components preconnected to terminal strips within control box to facilitate field connection to power source and push-button operating station.

C. Furnish and install a constant pressure operating station for the control and operation of each door at locations indicated. Stations in public accessible areas shall be key switched. Key cylinder shall be furnished under Section 08 71 00, Door Hardware.

D. Electric operator (motor) shall be fully automatic, furnished complete as specified.

E. All doors shall have over-ride manual operating capability. An emergency hand crank operator shall be provided to operate the door in case of power failure or removal of motor for inspection or servicing. The motor disengaging shall be accomplished by an eye hook using the hand crank.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Roll-up (coiling) service doors shall be installed by the manufacturer or its authorized representative, employing only workers and mechanics skilled and experienced in

the installation of the type of work involved. Doors shall be installed as indicated and in accordance with the approved Shop Drawings and the manufacturer's installation instructions and recommendations.

B. After installation is complete, the Contractor shall demonstrate to the District that the doors operate properly in accordance with the manufacturer's specifications and recommendations.

C. Verify that operating controls, manual controls, bypass and safety devices are operating properly.

D. The Contractor shall instruct District personnel in the operation of the doors.

3.02 MAINTENANCE

A. The Contractor shall provide call-back maintenance service for a period of one year, beginning from the date of Acceptance of the Work.

END OF SECTION 08 33 19

SECTION 08 33 23

OVERHEAD COILING GRILLES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Roll-up (coiling) grilles.

B. Power operating equipment.

1.02 RELATED SECTIONS

A. Section 08 71 00, Door Hardware.

1.03 MEASUREMENT AND PAYMENT

A. General: Separate measurement or payment will not be made for the work required under this Section. All costs in connection with the Work specified herein will be considered to be included or incidental to the Work of this Contract.

1.04 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings and Product Data: Submit detailed Shop Drawings and manufacturer's product data of overhead coiling grilles, including installation details and wiring diagrams.

C. Operation and Maintenance Data:

1. Submit operation and maintenance data in accordance with requirements of Section 01 78 23, Operation and Maintenance Data.

2. Submit recommended spare parts list, together with parts' numbers and prices, and photographs or cuts of repair parts.

3. Submit operation and maintenance manual containing printed instructions relative to operation, adjustment, care, and maintenance of the equipment. Include wiring diagrams showing field changes, if any.

1.05 QUALITY ASSURANCE

A. Provide the services of a manufacturer's representative, experienced in the installation, operation, and maintenance of overhead coiling grilles of the type specified, for technical assistance and advice during installation and testing.

1.06 SPARE PARTS

A. Provide one set of critical spare parts for each grille, boxed and identified, including installation instructions, wiring diagrams, and other information as necessary to make emergency repairs.

PART 2 – PRODUCTS

2.01 ROLL-UP (COILING) GRILLES

A. Type and Manufacture: Roll-up (coiling) grilles shall be motor-operated, Type 316 stainless steel roll-up type grille, face-mounted or mounted within the opening as indicated. Grilles shall be counter-balanced for smooth and easy operation. Components visible by patrons shall be Type 316 stainless steel.

B. Curtain: Grille curtain shall consist of 5/16 inch diameter horizontal Type 316 stainless steel rods at 1-1/2 inches on center, connected by 3/16 inch thick by 5/8 inch deep stainless steel links at no more than six inches on center connected to and between double links in a straight pattern, assembled to prevent horizontal movement of the links. Connect ends of horizontal rods with a continuous link assembly and end locks to prevent lateral movement of the curtain and to retain the horizontal bars in the guides. Bottom Rail: Stainless steel tube, two inch deep by four inch tall by 1/8 inch thick.

C. Curtain Guides: minimum of 3/6 inch thick, Type 316 stainless steel. Curtain guides shall have replaceable wear strips, minimum 1/2 inch by 1/2 inch cross section, made of ultraviolet proof plastic or nylon material. Wear strips shall be fastened to each side of the curtain guide with bolts with 8 inch off center maximum. Bolt heads shall be countersunk into wear strip 3/8 inch minimum and lock nut secured from the outside of stainless steel grille guide. Screws shall not be used for this application.

D. Mounting Brackets: Rolled steel plate designed to support the weight of the curtain along with its operating devices, resist the thrust of operation, and act as a closure for the hood.

E. Barrel: Seamless steel pipe, four inches or larger in diameter, designed to rotate about the torsion rod on permanently lubricated and sealed, self-aligning, ball-bearing races, with deflection limited to 0.03 inch per foot when fully loaded with weight of curtain. Provide rings about the barrel, shaped to permit nesting of the curtain. Secure these rings to barrel at 4 inches from each edge of the curtain and at not more than eight feet on center between.

F. Counterbalance: Oil-tempered, helically-wound springs, stress-relieved after coiling, attached at one end to the barrel through a cast iron anchor and to the torsion rod at its other end by a similar device. Counterbalance shall provide support of curtain as required to permit operation with not more than 50 pounds pull on the operating device.

G. Torsion Rod: High-tensile, case-hardened carbon steel, sufficiently long to penetrate the balancing springs, anchors, bearings, and torsion adjustment wheel. Adjustment wheel shall be outside the mounting bracket and accessible at all times.

H. Hood: Manufacturer's standard configuration for face mounting or head mounting within the frame, as indicated, minimum 24 gauge, Type 316 stainless steel. Exposed hoods shall be Type 316 stainless steel. Overhead Grill Hood shall be divided into sections not exceeding 6 feet in length. Sections shall be removable without tools, hood shall cover entire grille. Motor hood shall be a one piece hood connected to the overhead grille hood. Motor hood shall have access panels removable without using tools.

2.02 POWER OPERATING EQUIPMENT

A. Roll-up (coiling) grilles shall be motor-operated, using Micanan model Pro-GHC or equal motor operator, equipped with external output shaft. Motor operator shall be securely mounted with diagonal braces to prevent movement of more than 1/8 inch in any direction during operation. Bearings in addition to gearbox output shaft bearings, model BHC 80 worm gear reducer with 1.375 inches minimum diameter steel output shaft motor operator, or equal. Motor operator shall be securely mounted with diagonal braces to prevent movement of more than 1/8 inch in any direction during operation. Motor operator output sprocket shall be ANSI No. 60, 24 tooth minimum size, machined of aluminum alloy, 6061-T6 or equal, designated for ANSI No. 60 minimum size, pre lubricate roller drive chain. All equipment and accessories necessary for the proper operation of grilles shall be provided. Motors shall provide sufficient power and correct gear ratio to move grille curtain at 9-12 inches per second.

B. Provide prewired power operator with operating components preconnected to terminal strips within control box to facilitate field connection to power source and operating station.

C. Provide key operated, maintained pressure type, with "Open" and "Close" positions. Door movement shall stop if key is released. Switch shall be spring loaded to center "off" position. Provide Falcon 7 bit, G keyway, O-bitted, standard core lock cylinder with two anti-rotation screws drilled and tapped into the cylinder. Key operators shall be located 40-48 inches above grade.

D. Roll-up (coiling) grilles shall be furnished complete with seal as hereinbefore specified.

E. Electric operator (motor) shall be fully automatic, furnished complete with key switch controls as hereinbefore specified and limit switch.

F. An emergency pull chain operator, which does not affect the timing of the limit switch, shall be provided as specified to operate the grille curtain in case of power failure or removal of motor for inspection or servicing. Hand crank rods are not acceptable.

PART 3 – EXECUTION

3.01 PREPARATION

A. Verify that size and configuration of openings to receive overhead coiling security grilles complies with indicated details and approved Shop Drawings.

B. Furnish templates and install anchoring devices for coiling grilles in adjacent supporting structure as required.

3.02 INSTALLATION

A. Roll-up (coiling) grilles shall be installed by the manufacturer or its authorized representative as indicated and in accordance with the approved Shop Drawings and the manufacturer's installation instructions and recommendations, employing only workers and mechanics skilled and experienced in the installation of the type of work involved.

B. After installation is complete, the Contractor shall demonstrate to the Engineer that the security grilles operate in accordance with the manufacturer's specifications and recommendations.

C. The Contractor shall instruct District personnel in the operation of the security grilles.

3.03 PERFORMANCE TESTS

A. Perform electrical and manual operation of the security grille, including activating safety interlocks, under the observation of the Engineer, to ensure that grille curtain is free of obstructions and operates smoothly through its full range of travel in both directions.

B. Verify that operating controls, manual controls, bypass and safety devices are operating properly.

3.04 MAINTENANCE

A. The Contractor shall provide call-back maintenance service for a period of one year, beginning from the date of acceptance of this work by the District.

END OF SECTION 08 33 23

SECTION 08 51 16

ALUMINUM WINDOWS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Aluminum windows.

B. Baked finish.

C. Hardware.

D. Weatherstripping.

E. Glass and glazing.

F. Anchoring devices and fasteners.

G. Electrolytic bituminous isolation coating.

H. Sealants.

1.02 RELATED SECTIONS

A. Glass and glazing are specified in Contract Specifications Section 08 80 00, Glazing.

B. Restoration and replacement of existing windows are specified in Contract Specifications Section 08 01 57, Window Restoration and Replacement.

1.03 MEASUREMENT AND PAYMENT

A. General: Aluminum windows will not be measured separately for payment but will be paid for as part of the Contract lump sum price for Architectural Work.

1.04 REFERENCES

A. American Architectural Manufacturers Association (AAMA), Window and Door Manufacturers Association (WDMA), Canadian Standards Association (CSA):

1. AAMA 2604 — Voluntary Specification, Performance Requirements and Test Procedures for High Performance Organic Coatings on Aluminum Extrusions and Panels

2. AAMA 1503.1 — Voluntary Test Method for Thermal Transmittance and Condensation Resistance of Windows, Doors, and Glazed Wall Sections

3. AAMA/WDMA/ CSA 101/I.S.2/ A440	North America Fenestration Standard/Specification for Windows, Doors, and Skylights

B. American Society for Testing and Materials (ASTM):

1. ASTM B221	Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
2. ASTM E283	Standard Test Method for Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen
3. ASTM E330/ E330M	Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights, and Curtain Walls by Uniform Static Air Pressure Difference
4. ASTM E331	Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference

1.05 REGULATORY REQUIREMENTS

A. In addition to the foregoing referenced standards, the regulatory requirements that govern the work of this Section include the following governing codes:

1. California Code of Regulations (CCR), Title 24, Part 2, California Building Code, Chapter 24, “Glass and Glazing”.

2. California Code of Regulations (CCR), Title 24, Part 6, California Energy Code, applicable requirements.

1.06 QUALITY ASSURANCE

A. Test Units:

1. Air, water, and structural test unit sizes and configuration shall conform with requirements of AAMA/WDMA/CSA 101/I.S.2/A440.

2. Thermal test unit sizes shall be four feet by six feet. Unit shall consist of a single typical vent.

B. Test Procedures and Performance: Windows shall conform to AAMA/WDMA/CSA 101/I.S.2/A440 requirements for the window types specified. In addition, windows shall meet the following performance requirements:

1. Air Infiltration Test:

a. With window sash and ventilators closed and locked, test unit in accordance with ASTM E283 at static air pressure difference of 6.24 pounds per square foot.

b. Air infiltration shall not exceed 10 cubic feet per minute per foot of perimeter crack length.

2. Water Resistance Test:

a. With window sash and ventilators closed and locked, test unit in accordance with ASTM E331 at static air pressure difference of 7.50 pounds per square foot.

b. There shall be no uncontrolled water leakage.

3. Uniform Load Structural Test:

a. With window sash and ventilators closed and locked, test unit in accordance with ASTM E330/E330M at a static air pressure difference of 80 pounds per square foot positive pressure and 80 pounds per square foot negative pressure.

b. At conclusion of the test, there shall be no glass breakage, permanent damage to fasteners, hardware parts, support arms, or actuating mechanisms, nor any other damage that would cause the window to be inoperable or otherwise defective.

4. Condensation Resistance Test (CRF):

a. With window sash and ventilators closed and locked, test unit in accordance with AAMA 1503.1.

b. Condensation resistance factor shall be not less than 51.

5. Thermal Transmittance Test (Conductive U-value):

a. With window sash and ventilators closed and locked, test unit in accordance with AAMA 1503.1.

b. Conductive thermal transmittance (U-value) shall be not more than 60 BTU per hour per degree Fahrenheit per square foot.

C. Drainage: Window design shall enable water entering or occurring within the system to drain to the exterior.

1.07 SUBMITTALS

A. General: Refer to Contract Specification Sections 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Show materials, sizes and shapes of members, details of fabrication and installation, and finish hardware.

C. Product Data: Submit window manufacturer's product data, including illustrative photos (catalog cuts) of the windows, operating and locking hardware, and color chart for selection of coating color.

D. Samples: Three feet by four feet sample of operable unit, of materials, finish and color specified; sample shall include polycarbonate glass, glazing, and hardware.

E. Test Reports: Test reports from AAMA accredited laboratories certifying specified performance. Furnish with specified certification.

F. Certification: AAMA Notice of Certification stating that the tested window meets or exceeds referenced criteria for AAMA/WDMA/CSA 101/I.S.2/A440 window type specified.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Refer to Contract Specifications Section 01 60 00, Product Requirements, for general requirements for delivery, storage, and handling procedures.

B. Do not allow windows or components to come in contact with mud, uncured concrete, materials that with the presence of moisture could cause staining of finish, and other materials that could damage windows or their finish.

1.09 WARRANTY

A. In addition to the guaranty requirements of the General Conditions, Article GC4.9, Guaranty of Work, furnish warranties specified below in a form acceptable to the Engineer. The warranty shall begin when the Guaranty of Work begins as specified in General Conditions Article GC4.9.

B. Total Window System:

1. Contractor shall warrant for three years the satisfactory performance of the total window installation, including windows, hardware, glass, glazing, anchorage and setting system, sealing, flashing, and associated items as it relates to air, water, and structural adequacy as specified and as indicated on approved Shop Drawings.

2. Deficiencies due to such elements not meeting specified requirements shall be corrected at Contractor's expense during the warranty period.

C. Finish Coating: Warrant finish fluoropolymer coating for five years for film integrity, and against color fade and chalking.

PART 2 – PRODUCTS

2.01 MATERIALS AND FABRICATION

A. Window Type: Monumental operable and fixed sash aluminum windows, as indicated, meeting requirements of AAMA/WDMA/CSA 101/I.S.2/A440, with baked fluoropolymer finish.

B. Aluminum: ASTM B221, 6063-T5 alloy and temper, extrusions of sizes indicated and of thickness required to meet specified design and performance requirements.

1. Extrusions:

   a. Minimum wall thickness shall be 0.125 inches.

   b. Depth of frame and sash shall be 2 7/16-inches minimum.

2. Frame Components: Mitered, reinforced with aluminum angle, and welded.

3. Sash:

   a. Extrusions shall be tubular.

   b. Each corner shall be mitered, reinforced with an extruded aluminum corner key, hydraulically crimped, and “cold-welded” with epoxy adhesive.

   c. Each operable sash shall have two rows of neoprene weatherstripping installed in specially designed dovetail grooves in sash extrusion.

4. Internal Components: Manufacturer’s standard stainless steel or other corrosion-resistant materials compatible with aluminum extrusions.

C. Baked Fluoropolymer Finish: Full 70 percent polyvinyldene fluoride finish. Only coatings based on fluoropolymer resins meeting requirements of AAMA 2604, will be accepted. Color shall be as selected and approved by the Engineer from manufacturer’s standards. All exposed aluminum surfaces shall receive the baked fluoropolymer finish.

D. Hardware:

1. Operating Handles: Locking handles shall be cam type manufactured from white bronze alloy with a US25D brushed finish. Furnish Allen keyed custodial lock and concealed limit stop.

2. Operating Arms: Pivot vents shall be extruded aluminum pivot housing with stainless steel pin.

E. Weatherstripping: Neoprene, for use between frame and vent.

F. Glass and Glazing: Factory glaze sash with clear float, insulating glass as specified in Contract Specifications Section 08 80 00, Glazing. Units shall be “wet glazed” with snap-in aluminum extruded glazing bead and PVC bulb on the interior of the glass. Exterior of glass shall be set in a continuous bead of silicone sealant. Provide for expansion and contraction of acoustical glass.

G. Anchoring Devices and Fasteners: Aluminum or stainless steel when exposed, cadmium- or zinc-plated steel when concealed.

H. Electrolytic Bituminous Isolation Coating: Asphalt- or Coal-tar pitch-based paint or varnish of heavy or thick consistency, or 1/16-inch thick neoprene or butyl tape.

I. Sealants: Refer to Contract Specifications Section 07 90 00, Joint Protection, for requirements.

PART 3 – EXECUTION

3.01 PREPARATION

A. Where aluminum is installed in contact with dissimilar metals, concrete, or masonry, the aluminum shall be painted with bituminous isolation coating or separated with neoprene or butyl tape.

B. Clean aluminum surfaces that will come in contact with sealants.

3.02 INSTALLATION

A. Install windows as indicated and in accordance with approved shop drawing, and the window manufacturer’s installation instructions and recommendations.

B. Plumb and align window faces in a single plane for each wall plane, and install windows square and true, adequately anchored to maintain positions permanently when subjected to normal thermal and building movement and specified wind loads.

C. Calk and seal windows completely around their perimeters with sealant and tape as required.

3.03 ADJUSTING

A. Adjust ventilators and associated hardware to operate smoothly, to provide a tight fit at contact points and weatherstripping, and to meet specified performance requirements. Following adjustment, leave operable units in closed position.

B. Apply sealants at joints and intersections and at opening perimeters. Wipe off excess material and leave exposed surfaces and joints clean and smooth.

C. Upon completion of installation, windows shall be inspected, adjusted, and operable units put into proper working order to operate smoothly.

D. All units shall be weathertight as specified.

3.04 CLEANING

A. Clean exterior and interior faces of windows free of labels, dirt, and other adhering foreign materials, using cleaning materials and methods recommended by the window and glass manufacturers.

END OF SECTION 08 51 16

SECTION 08 63 00

METAL-FRAMED SKYLIGHTS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Metal framed roof skylight.

B. Baked enamel finish.

C. Glass.

D. Glazing gaskets.

E. Fasteners and accessories.

F. Isolation coating.

G. Sealant.

1.02 MEASUREMENT AND PAYMENT

A. General: Metal-framed skylights will not be measured separately for payment but will be paid for as part of the Contract lump sum price for Architectural Work.

1.03 REFERENCES

A. American Architectural Manufacturers Association (AAMA):

1. AAMA/WDMA1600/ I.S.7 — Voluntary Specifications for Skylights
2. AAMA SDGS-1 — Structural Design Guidelines for Aluminum Framed Skylights
3. AAMA 2603 — Voluntary Specification, Performance Requirements and Test Procedures for Pigmented Organic Coatings on Aluminum Extrusions and Panels (with Coil Coating Appendix)
4. AAMA 2604 — Voluntary Specification, Performance Requirements and Test Procedures for Pigmented Organic Coatings on Aluminum Extrusions and Panels (with Coil Coating Appendix)
5. AAMA 2605 — Voluntary Specification, Performance Requirements and Test Procedures for Superior Performancing Organic Coatings on Aluminum Extrusion and Panels (with Coil Coating Appendix)

B. American Society for Testing and Materials (ASTM):

1. ASTM E283 Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen

2. ASTM C920 Standard Specification for Elastomeric Joint Sealant

1.04 REGULATORY REQUIREMENTS

A. In addition to the foregoing referenced standards, the regulatory requirements that govern the work of this Section include the following governing code:

California Code of Regulations (CCR), Title 24, Part 2, California Building Code, Chapter 15, “Roof Assemblies and Rooftop Structures,” and Chapter 24, Section 2405, “Sloped Glazing and Skylights.”

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings and Product Data: Submit detailed Shop Drawings and manufacturer’s product data of the roof skylight, giving sizes, details of fabrication and construction, glass data, coatings data, color chart, method of assembly, locations and types of anchors, and related work.

C. Samples: Submit samples of lengths of coated metal framing, in color as selected. Color-coated metal surfaces require approval of the Engineer.

1.06 DESIGN AND QUALITY ASSURANCE

A. Conform with requirements of the California Building Code, Chapters 15 and 24, AAMA/WMDA 1600/I.S.7, and AAMA SDGS-1, as applicable.

B. Design and Responsibility: Roof skylight shall be designed, fabricated, and installed by a skilled and experienced supplier/installer specializing in the design, manufacture, and installation of custom skylights.

C. Design Criteria: Comply with the hereinbefore specified Reference Standards and the following:

1. Structural Design Requirements: California Building Code, Chapters 15 and 24; maximum deflection: 1/240.

2. Live Load: 40 pounds per square foot.

3. Wind Loads: Comply with CBC, Chapter 16, Section 1609, Wind Load. Risk category shall be the same as the risk category of the structure and Exposure C. The minimum wind loads shall be 30 pounds per square foot, positive and negative.

4. Seismic Design: Calculations of seismic loading and design for seismic conditions shall be in accordance with the California Building Code, Chapter 16 and Chapter 16A, Structural Design.

5. Thermal Movement: Provide for noiseless expansion and contraction that may be caused by a temperature range of 100 degrees Fahrenheit.

6. Weathertight Integrity:

    a. Water Penetration: None.

    b. Air Infiltration: Maximum of 0.06 cubic foot per minute when tested in accordance with ASTM E283.

7. Glass Safety Factor: 2.5.

1.07 GUARANTY

A. In addition to the guaranty requirements specified in the General Conditions, Article GC4.9, roof skylight and related flashings shall be guarantied against leakage, defective materials, and poor work quality of the completed work. Any such defects or leakage occurring during the period of the guaranty shall be promptly and completely corrected, including all affected work, at no additional cost to the District.

B. Said guaranty shall be in effect for a period of five years from the date of Certificate of Substantial Completion issued by the District. The guaranty shall be signed by the skylight installer and countersigned by the Contractor, and shall be submitted to the Engineer prior to acceptance of the skylight work.

C. In addition, submit coating system manufacturer’s standard 20-year warranty for the fluoropolymer baked-enamel finish as herein specified.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Skylight Type: Skylight shall be custom-designed and -fabricated, metal-framed roof skylight, conforming with the details and dimensions indicated.

B. Baked-Enamel Finish:

1. Coating System: Exposed metal framing shall be coated and finished with a baked fluoropolymer enamel coating system. Color shall be a standard color as selected and approved by the Engineer from manufacturer’s standards.

a. Heads of exposed fasteners shall be coated to match color of adjacent baked enamel finish.

2. Coating Performance: Final coating shall conform with the ASTM performance and test requirements specified in AAMA 2603, AAMA 2604, AAMA 2605.

C. Glass: Comply with requirements indicated and the California Building Code, Chapter 24, Glass and Glazing.

D. Glazing Gaskets: Extruded synthetic rubber, continuous glazing gaskets, tape, or strip, as recommended by the skylight manufacturer.

E. Fasteners and Accessories: Furnish anchors and fasteners, washers, straps, and accessories required for a complete and finished installation. Fasteners connecting framing members and fasteners exposed to weather shall be Type 304 or Type 316 stainless steel. Interior fasteners shall be stainless steel with heads coated to match baked-enamel finish. Fasteners shall have rubber gaskets or washers under heads, nuts, and metal washers.

F. Isolation Coating: Framing members to be in contact with concrete, wood, plaster, or dissimilar metals shall be painted with a heavy coat of alkali-resistant bituminous paint.

G. Sealant: Silicone synthetic rubber elastomeric sealant that cures at normal temperature to a flexible firm rubber, tack free, and designed for adhesion to the surfaces to which it will be applied. Sealant shall meet or exceed the minimum requirements of ASTM C920.

2.02 FABRICATION

A. Roof skylight shall be custom designed and fabricated to suit building conditions and roof opening, of sizes and configurations indicated.

B. Sizes and design characteristics of the framing members shall be as required by opening spans to carry a minimum live load of 40 pounds per square foot with a maximum fiber stress of 13,000 pounds per square inch and maximum deflection of 1/240 at center of span and as specified in Article 1.05.C.

C. Metal framing shall be prefabricated and preassembled in the factory or shop as far as practicable. Welding shall be performed in the shop by qualified welders as specified in Section 05 05 22, Metal Welding. Welds exposed to view shall be ground and dressed smooth.

D. Provide for expansion and contraction in the fabrication and assembly of metal framing.

E. Provide for drainage of condensation to the exterior. Curbs shall be provided with condensation weep holes.

F. Glass shall be continuously supported on glazing gaskets or tape at all bearing surfaces, top and bottom. Gaskets or tape shall be compressed a minimum of 15 percent all around to form a tight seal. There shall be no glass surfaces bearing on metal. Gaskets and sealing tape shall be continuous and shall seal glass and metal watertight. Provide for 5/8-inch minimum grip of glass and for expansion and contraction of glass.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Skylight shall be installed and glazed by the manufacturer or its authorized representative as indicated and in accordance with the approved Shop Drawings and the manufacturer's installation instructions and recommendations, using only workers skilled and experienced in this type of work.

B. Ample provisions shall be made in flashings and assemblies for expansion and contraction. Skylight shall be watertight after installation and completion of the work.

C. Skylight assembly shall be set on curb in continuous bead of sealant. Skylight assembly and flashings shall be calked and sealed with sealant as required for a watertight installation. Calking and sealing work shall conform with applicable requirements of Section 07 90 00, Joint Protection.

3.02 TESTS

A. Skylight installation shall be watertight, and water tests to prove this shall be conducted by the Contractor, under the observation of the Engineer. Water tests shall be performed in conjunction with roofing water tests. Tests shall be performed before work is started on interior finishes.

END OF SECTION 08 63 00

SECTION 08 71 00

DOOR HARDWARE

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Door hardware.

B. Public safety key box.

C. Coordination of interfaces among security and access control equipment, door hardware, doors, and frames.

1.02 MEASUREMENT AND PAYMENT

A. General: Door hardware will not be measured separately for payment but will be paid for as part of the Contract lump sum price for Architectural Work.

1.03 REFERENCE STANDARDS

A. American National Standards Institute/Builders Hardware Manufacturers Association (ANSI/BHMA):

1. ANSI/BHMA A156 Standards Set
2. ANSI/BHMA A156.3 Exit Devices
3. ANSI/BHMA A156.4 Door Controls - Closers

B. National Fire Protection Association (NFPA):

1. NFPA 80 Standard for Fire Doors and Other Opening Protectives

1.04 DESIGN REQUIREMENTS

A. Exit Doors: Openable at all times from the inside without the use of a key or any special knowledge or effort.

B. Fire-Rated Openings: Provide hardware for fire-rated openings in compliance with NFPA 80. This requirement takes precedence over other requirements for such hardware. Provide only such hardware which has been tested and listed by a nationally recognized testing laboratory for the type and size of door required, and complies with the requirements of the door and the door frame labels. Latching hardware, door closers, ball bearing hinges, and seals are required for fire-rated openings whether or not listed in the hardware schedule.

1. Provide hardware listed by nationally recognized testing laboratory for labeled and 20-minute openings in conformance with requirements for class of opening scheduled. Provide label or stamp of nationally recognized testing laboratory on hardware for labeled openings.

2. Where panic exit devices are required on fire-rated doors, provide supplementary marking on door's testing laboratory label on panic exit device indicating "Fire Exit Hardware."

C. Furnish all items of hardware required to complete the work in accordance with Contract Documents. Provide all items required for a complete functional operation and code compliance at each door opening. Items not specifically mentioned but necessary to complete the work shall be furnished, matching in quality and finish the item specified for similar locations.

D. Provide hardware with suitable fasteners for complete work.

E. Quantities listed are for the Contractor's convenience; confirm quantities.

F. If the grade of an item designated by ANSI/BHMA designation is not indicated, provide Grade 1.

G. Hand of Door: Contract Drawings show direction of swing or hand of each door leaf. Furnish each item of hardware for proper installation and operation of door movement as shown.

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Coordinate submittal of door hardware with submittals of related items including metal doors and frames and electrified components to be integrated with doors.

C. Submit door hardware schedule organized into "Hardware Sets" with an index of doors and heading indicating complete designations of every item required for each door or opening. Include the following information:

1. Type, style, function, size, quantity, and finish of each hardware item.

2. Name, part number, and manufacturer of each item.

3. Fastenings and other pertinent information.

4. Location of hardware set cross-referenced to indications on Contract Drawings both on floor plans and in door schedule.

5. Explanation of abbreviations, symbols, and codes contained in schedule.

6. Mounting locations including heights for hardware.

7. Door and frame sizes and materials.

D. Wiring Diagrams: Submit wiring diagrams, if applicable, tailored for each applicable opening including electric hardware, security equipment, and access control equipment. Indicate and coordinate with door and frame rough-ins required.

E. Product Data:

1. Manufacturers' technical data and installation instructions.

2. Catalog cuts, marked to indicate applicable item.

F. Samples: If requested by the Engineer, submit one sample of each type of hardware. Samples will be returned, and approved samples may be used in the work.

G. Templates: Where required, furnish hardware templates to each fabricator of doors, frames, and other work to be factory-prepared for the installation of hardware.

H. Keying Schedule: Submit separate detailed schedule indicating clearly how the Engineer's final instructions on keying of locks has been fulfilled.

I. Supplier's AHC Inspection: Submit report and written statement signed by the AHC that its inspection has been completed as specified under the Article entitled "Adjusting" herein.

J. Operation and Maintenance Manual: Submit in accordance with Section 01 78 23, Operation and Maintenance Data. Include record "as installed" copy of final hardware schedule. Include "as installed" wiring diagrams for each piece of hardware connected to power.

1.06 QUALITY ASSURANCE

A. Supplier Qualifications: Firm with three years' experience in distribution of commercial/institutional hardware who has in its employ a certified architectural hardware consultant (AHC) who is available at reasonable times during the course of the Work for consultation to the Engineer and Contractor. AHC shall be responsible for scheduling and coordinating hardware and establishing keying schedule.

B. Obtain each kind of hardware (latch and locksets, panic exit devices, hinges, and closers) from only one manufacturer.

C. Keying Schedule Meeting: Conduct keying meeting with the Engineer, hardware supplier, AHC, and other District representatives. Review door security level, functionality, keying, and programming of locksets and locking hardware. Provide copies of proposed keying and programming schedule for use at the meeting.

D. Security Hardware Coordination: For doors with electrical and electronic interfaces conduct the following coordination:

1. Conduct a detailed shop drawing review working session (Working Session) to coordinate security system, door hardware, doors and frames, and associated conduits, wiring, and power provisions.

    a. Participants shall include the Contractor, the Engineer, AHC, and representatives of the various subcontractors and suppliers involved in the supply and installation of the work being coordinated. Schedule and hold meeting within 120 Days following the Notice to Proceed.

2. Submit one copy of each related security, door hardware, and door and frame submittals a minimum of seven Days prior to Working Session for preliminary review.

3. In Case of Incomplete Submittal:

    a. If the Engineer notifies the Contractor that the submittals are incomplete, the Contractor shall postpone and reschedule the Working Session for a date no later than 30 Days from the date of notification.

    b. Correct deficiencies in submittals and repeat the submittal of one copy of each of the related submittals for preliminary review a minimum of seven Days prior to Working Session. (Process shall continue until the Engineer deems that the submittals are sufficiently complete for the Working Session.)

4. Working Session Submittal: The Contractor shall compile all comments and changes discussed in the Working Session into a Working Session Submittal and submit this document along with the required number of sets of the corrected submittals (related security, door hardware, and door and frame submittals).

5. Conduct additional Working Sessions and submittal review cycles if determined necessary by the Engineer.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Acceptance at the Site: Deliver products in original unopened packaging with legible manufacturer's identification. Individually package each unit of finish hardware complete with proper fastening and appurtenances, clearly marked on the outside to indicate contents and specific locations in the Work. Include installation instructions. Mark hardware to correspond with approved hardware schedule.

B. Deliver packaged hardware items at the times and to the locations (shop or field) for installation, as appropriate and in accordance with the progress schedules.

1.08 PROJECT CONDITIONS

A. Coordination: Coordinate hardware with other work. Furnish hardware items of proper design for use on doors and frames of the thickness, profile, swing, security and similar requirements indicated, as necessary for the proper installation and function.

B. Verify that doors and entrances will incorporate adequate provisions for the proper installation of hardware.

1.09 WARRANTY

A. Provide manufacturers' guarantees as follows:

1. Closers, Except Electronic Closers: Ten years.

2. Electronic Closers: Two years.

3. Panic Exit Devices and Locksets: Three years.

4. All Other Hardware: Two years.

1.10 DISTRICT INSTRUCTION

A. Instruct District personnel in operation and maintenance of hardware units. Refer to Section 01 79 00, Demonstration and Training.

1.11 MAINTENANCE MATERIALS

A. Provide wrenches and tools furnished by manufacturers as required for proper maintenance of hardware. Clearly label wrenches and tools. Provide two sets of such wrenches and tools to the Engineer.

PART 2 – PRODUCTS

2.01 PRODUCTS

A. Manufacturer's Name Plate: Do not use manufacturer's products which have manufacturer's name or trade names displayed in a visible location (omit removable nameplates), except in conjunction with required UL or FM labels and as otherwise approved by the Engineer.

1. Manufacturer's identification will be permitted on rim of lock cylinders only.

B. Hinges: Outswinging exterior doors and doors which swing out from an employee only or private area into a public area or corridor shall have non-removable pin hinges. Specified hinge open widths shall be understood to be minimum, but shall be of sufficient size to permit door to swing 180 degrees. Hinges shall be non-rising. Furnish hinges with five knuckles and flush bearing.

1. Furnish three hinges per leaf to seven foot six inch height. Add one for each additional 30 inches in height or fraction thereof.

2. Provide hinges as listed in schedule.

C. Locksets and Cylinders

1. Locksets and cylinders: Designated Matching Products specified in Contract Specifications Section 08 71 00, Door Hardware. Locksets shall be pin tumbler, standard small format interchangeable core, 7 pin, A626 finish. Keyway shall be according to security level.

2. Lockset Backset: 2-3/4 inches.

3. If electrified, use a 24V DC voltage fail secure.

4. Door Lever: Designated Matching Product.

D. Strikes: Provide lockset manufacturer's standard wrought box strike for each latch or lock bolt, with extended lips to protect frame, finish to match hardware set.

1. Provide flat lip strikes for locks with three-piece, anti-friction latchbolts as recommended by manufacturer.

2. Provide dust-proof strikes for foot bolts, except where special threshold construction provides non-recessed strike for bolt.

3. Provide roller type strikes where recommended by manufacturer of the latch and lock units.

4. Provide 24V DC strike fail to secure if controlled electronically.

E. Panic Exit Devices: Designated Matching Product, ANSI/BHMA A156.3, Grade 1, 626, 26D finish. Trim of exits to match trim of locksets, unless specified otherwise.

F. Surface Door Closers: ANSI/BHMA A156.4, Grade 1. Heavy-duty arms and knuckles. Full rack and pinion type with removable non-ferrous cover, 1 1/2 inch minimum bore. Place closers inside building, stairs, and rooms. Provide appropriate closer type so that closers are not visible to public view.

1. Closers shall be non-handed, non-sized, adjustable, and multi-size one through six.

2. Drop brackets are required at narrow head rails.

3. Set exterior doors closers to have eight and one half pounds maximum pressure to open, interior non-rated at five pounds, rated openings at 12 pounds.

4. Separate adjusting valves for closing and latching speed, and backcheck.

G. Kickplates: Provide with four beveled edges, ten inches high by width less two inches on single doors and one inch on pairs of doors. Furnish pan-head countersunk screws to match finish.

H. Screws: All exposed screws shall be Phillips head.

I. Silencers: Furnished under Section 08 11 00, Metal Doors and Frames. Omit where seals occur.

J. Stops: Provide at minimum two stops for swing doors at opposite ends. Provide heavy-duty wall stops with concave rubber bumpers. Whenever wall stops are not practical use dome style heavy-duty floor stops. In instances where neither a wall nor door stop is practical, provide closer with a 90-degree swing with increased back-check.

K. Astragal: Provide for double door set.

L. Thresholds: Provide thresholds in single length for each opening with ends scribed or shaped to seat snugly against jamb profiles.

M. Weatherstripping and Seals:

1. Except as otherwise indicated, provide continuous weatherstripping at each edge of every exterior door leaf: heads, jambs, and astragals of doors.

2. Seals: Seals shall be finished to match adjacent frame color as approved by the Engineer. Material shall be listed by a nationally recognized testing laboratory for labeled openings.

3. Replaceable Seal Strips: Provide only those units where resilient or flexible silicone seal strip is easily replaceable and readily available from stocks maintained by manufacturer.

4. Weatherstripping:

    a. At jambs and heads, provide bumper-type resilient insert with retainer strips, surface applied.

    b. At astragals, provide a compression bulb resilient pressure sensitive door gasketing.

5. Door Bottoms: Provide handed, surface mounted units with sponge neoprene seal.

N. Door Bolts: Provide manual flush bolts at tops and bottoms of inactive leaf of each pair of doors, with minimum of one half inch diameter rods.

O. Public Safety Key Box: Provide a public safety key box 6 inches by 6 inches in size of extra heavy-duty vault construction with drill-resistant door, recessed mounted. Finish as specified in the Contract Specifications Section 08 71 00, Door Hardware, in accordance with local Fire Department requirements.

2.02 FINISH

A. Typical Finish: BHMA 630 satin stainless steel, unless otherwise noted.

B. Protection Plates, Push, Pulls, Panic Exit Devices, Locksets and Mortise Locks: BHMA 630 satin stainless steel, unless otherwise noted.

C. Door Closer Finish: Factory power coat to match other hardware, unless otherwise noted.

2.03 KEYING REQUIREMENTS

A. Notify the Engineer in writing a minimum of two weeks prior to construction start the number of permanent cores to be installed. The Contractor shall submit the permanent uncoded cores and keys blanks per Article 2.03 herein to the District. The District will furnish construction pinned and keyed cores and keys for installation and use during the construction period. Construction control and operating keys and core are not part of the District's permanent key system and are not furnished on the same keyway as the District's permanent keying system.

B. Notify the Engineer in writing a minimum of two weeks prior to occupancy to allow enough time to schedule re-keying to the permanent cores which will be performed by the District locksmith.

C. Return construction keys to the Engineer prior to Acceptance.

D. Permanent keys and cores shall be stamped with the applicable key mark for identification. These visual key control marks or codes shall not include the actual key cuts. Permanent keys shall be stamped "Do Not Duplicate."

E. Furnish key blanks in the following quantities:

1. Four each Masterkeys blanks per lock.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install each hardware item per manufacturer's instructions and recommendations. Do not install surface mounted items until finishes have been completed on the substrate. Set units level, plumb and true to line and location. Adjust and reinforce the attachment substrate as necessary for proper installation and operation.

B. Electrified Hardware: For cable termination to electrified hardware, provide coordination so that cable is routed to door from transfer hinge to lockset, prior to buttoning up.

C. Install hardware using fasteners provided by the respective manufacturer suitable for application. Drill and tap screw holes in metallic materials.

3.02 HARDWARE LOCATIONS

A. Hinges:

1. Bottom Hinge: 10 inches from door bottom to bottom of hinge.

2. Top Hinge: Five inches from door top to top of hinge.

3. Center Hinge: Center between top and bottom hinge.

4. Extra Hinge: Six inches from bottom of top hinge to top of extra hinge.

B. Lockset: Thirty-eight inches from finished floor to center of lever or knob.

C. Panic Exit Device: Forty-four inches from bottom of door to center of bar.

D. Push Plate: Forty-four inches from bottom of door to center of plate.

E. Pull Plate: Forty-two inches from bottom of door to center of pull.

F. Deadlock Strike: Locate to fit with the panic exit device.

3.03 ADJUSTING

A. Adjust and check each operating item of hardware and each door to ensure proper operation or function of every unit. Replace units which cannot be adjusted to operate freely and smoothly.

B. Manufacturer/Distributor's Field Services: After installation is complete, provide the services of hardware supplier's AHC for an inspection. AHC shall inspect completed door openings to verify installation of hardware is complete and properly adjusted, in accordance with both the Contract Documents and final approved submittals. Further adjust hardware as necessary during inspection. Perform inspection in the presence of the Engineer and District maintenance personnel.

1. Check closers to ensure proper operation.

2. Check latchset, lockset, and panic exit devices are properly installed and adjusted to ensure proper operation.

   a. Verify levers are free from binding.

   b. Ensure latchbolts and dead bolts are engaged into strike and hardware is functioning.

3. Report findings, in writing, outlining corrective actions and recommendations.

C. Final Adjustment: Whenever hardware installation is made more than one month prior to Revenue Service or occupancy of a space or area, as applicable, return to work during the week prior to Revenue Service or occupancy, and make final check and adjustment of all hardware items in such space or area. Clean operating items as necessary to restore proper function and finish of hardware and doors. Adjust door control devices to compensate for operation of heating and ventilating equipment.

1. For door closers, provide final adjustment of door closers to ensure that all doors close and latch properly to prevent false door held alarms or intrusions and compliance with maximum opening pressure.

    a. Adjust closer to complete full closing cycle in less than four to six seconds without abrupt change of speed between “sweep” and “latch” speeds.

    b. Adjust “back-check” according to manufacturer’s instructions.

2. Power Up and Test: Provide powered up testing of doors in the presence of the installer of electrified hardware, as applicable, to ensure final adjustments to electrified components.

3. During final adjustment of hardware, instruct District personnel in proper adjustment and maintenance of hardware and hardware finishes. This training shall be coordinated with training conducted in accordance with Section 01 79 00, Demonstration and Training.

3.04 HARDWARE SCHEDULE

A. Schedule Designations: Typically, the numeric designations of specific manufacturers are used in the schedule for each item to indicate design, size, weight, finish function, and other features. With the exception of Designated Matching Products, products of other manufacturers will be acceptable if such products include the same features as the product listed. Refer to the General Conditions for provisions regarding trade names and alternatives.

B. Refer to Hardware Schedule in the Contract Specifications Section 08 71 00, Door Hardware.

END OF SECTION 08 71 00

SECTION 08 80 00

GLAZING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Glass.

B. Glazing.

1.02 RELATED SECTIONS

A. Contractor, at its option, may furnish doors and windows factory-glazed and deliver such doors and windows to the site pre-glazed. Glass and glazing of factory-glazed doors and windows shall conform with the requirements specified herein.

1.03 MEASUREMENT AND PAYMENT

A. General: Glass and glazing will not be measured separately for payment but will be paid for as part of the Contract lump sum price for Architectural Work.

1.04 REFERENCES

A. American National Standards Institute (ANSI):

1. ANSI Z97.1 Safety Glazing Materials Used in Buildings - Safety Performance Specifications and Methods of Test

B. American Society for Testing and Materials (ASTM):

1. ASTM C509 Standard Specification for Elastomeric Cellular Preformed Gasket and Sealing Material
2. ASTM C864 Standard Specification for Dense Elastomeric Compression Seal Gaskets, Setting Blocks, and Spacers
3. ASTM C920 Standard Specification for Elastomeric Joint Sealants
4. ASTM C1036 Standard Specification for Flat Glass
5. ASTM C1048 Standard Specification for Heat-Strengthened and Fully Tempered Flat Glass
6. ASTM C1172 Standard Specification for Laminated Architectural Flat Glass
7. ASTM D790 Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

8. ASTM D2240 Standard Test Method for Rubber Property-Durometer Hardness

9. ASTM F36 Standard Test Methods for Compressibility and Recovery of Gasket Materials

C. Code of Federal Regulations (CFR):

1. Title 16, Part 1201 Safety Standard for Architectural Glazing Materials

D. Glass Association of North America (GANA):

1. GANA Glazing Manual

E. National Fire Protection Association (NFPA):

1. NFPA 80 Standard for Fire Doors and Other Opening Protectives

F. Underwriters Laboratories (UL):

1. UL 752 UL Standard for Safety Bullet-Resisting Equipment

1.05 REGULATORY REQUIREMENTS

A. In addition to the foregoing referenced standards, the regulatory requirements that govern the work of this Section include the following governing code:

1. California Code of Regulations (CCR), Title 24, Part 2, California Building Code, Chapter 24, “Glass and Glazing”.

1.06 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Product Data: Submit manufacturer’s product data indicating compliance with specified requirements.

C. Samples:

1. Submit 8-inch by 10-inch sample of each type, thickness, and color of glass to be installed. Identify each sample with the manufacturer’s name, product name, type of glass, thickness, color designation, and installation location. Protect sample edges for handler’s safety.

2. Submit 10-inch samples of each type of glazing gasket, and tape, and glazing compound, identified with manufacturer’s name, product name, and type of material.

D. Certificates: Submit certification that insulating glass units furnished and installed are faithful replicas of insulating glass units that have passed the program of manufacturer's testing.

1.07 QUALITY ASSURANCE

A. Regulatory Requirements: Glass and glazing shall comply with applicable requirements of the California Building Code, Chapter 24, ANSI Z97.1, and Title 16 of CFR, Part 1201.

B. Tempered Glass:

1. Tempered and heat strengthened glass shall be horizontally treated; vertical treatment will not be acceptable. Fabrication and treatment shall be such that roller distortion lines (where they may occur) run horizontally (parallel to sill and head) after installation.

2. Tempered glass shall bear the manufacturer's identification as to type and thickness. Such identification for glazing shall be permanently etched so as to be visible after glass has been installed. Glass other than fully tempered (FT) glass shall not have etched labels.

C. Identification: Label each pane of glass and glass unit with type, thickness, quality, and color of glass and with manufacturer's trade name.

D. Glazing: Glazing compounds and methods of glazing shall conform with applicable requirements of GANA Glazing Manual.

PART 2 – PRODUCTS

2.01 GLASS

A. Glass Standards and Requirements: Glass materials shall conform with ASTM C1036 for float glass and ASTM C1048 for heat-strengthened and tempered glass, as applicable. Types and thicknesses of glass shall be as indicated.

B. Clear Float Glass: ASTM C1036, Type I, Class 1, with flat, smooth, and glossy surfaces for architectural glazing.

C. Tinted Float Glass: ASTM C1036, Type I, Class 2, of tint color indicated, with flat, smooth and glossy surfaces for architectural glazing.

D. Wired Glass: ASTM C1036, Type II, Class 1, Form 1, Mesh m1-Diamond or m2-Square as indicated. Glass for fire-rated doors shall conform with applicable requirements of NFPA 80.

E. Clear Tempered Glass: ASTM C1048, Kind FT, Condition A, Type I, Class 1.

F. Tinted Tempered Glass: ASTM C1048, Kind FT, Condition A, Type I, Class 2, of tint color indicated.

G. Laminated Tempered Glass: Made up of two panes of fully tempered (FT), Type I, Class 1, glass of thicknesses indicated, with special 0.060-inch vinyl interlayer, meeting requirements of ASTM C1172.

H. Insulating Glass: Preassembled unit, comprising two organically sealed panes of clear tempered glass separated by dehydrated (desiccated) air space, of sizes and thicknesses indicated.

I. Bullet Resistant Plastic Glass: Monolithic or laminated polycarbonate sheets. Exterior shall be mar resistant. The assembly shall have a flexure strength of not less than 13,500 psi in conformance with ASTM D790; have 87 percent light transmission; weigh not more than 5.1 lbs/sq.ft., and meet UL 752 Level 1 Bullet Resistant Acrylic.

2.02 GLAZING MATERIALS

A. Setting Blocks and Spacers: ASTM C864, semi-hard neoprene or vinyl rubber, 70-90 Shore A hardness when tested in accordance with ASTM D2240, of width equal to thickness of glass and long enough to limit load on each block to 15 pounds per square inch. Minimum length of setting blocks shall be 3 inches.

B. Glazing Gaskets: Continuous, closed-cell, extruded neoprene or vinyl rubber, channel type, manufactured for glazing in type of metal doors and frames indicated, conforming with applicable requirements of ASTM C509. Color shall be as selected by the Engineer from manufacturer’s standards. Gaskets shall be capable of being compressed 40 percent of original size and shall have 100 percent recovery capability when tested in accordance with ASTM F36.

C. Glazing Tape: Synthetic rubber sheet or strip material reinforced and stabilized with fabric mesh in center and treated with a bonding agent on both contact surfaces.

D. Glazing Compounds:

1. For Face Glazing: Elastic glazing compound, manufactured for back bedding and face glazing of metal sash, in color as selected by the Engineer from manufacturer’s standards.

    a. Include window manufacturer’s glass-retaining glazing clips for face glazing.

2. Elastomeric Joint Sealant: Sealant for glass to glass edge joints shall be a silicone sealant conforming with ASTM C920, black in color.

3. For Channel Glazing: Elastomeric glazing compound, manufactured for glazing with metal stops and glazing beads of metal sash, conforming with applicable requirements of the GANA Glazing Manual, in color as selected by the Engineer from manufacturer’s standards.

PART 3 – EXECUTION

3.01 PREPARATION

A. Obtain field dimensions of each opening that is to receive glass and cut each light to provide the optimal bite on, and clearance from, the sash or frame.

B. Clean the surfaces that are to receive glass and glazing materials. Surfaces shall be free of dirt, corrosion, residue, and any other substance that may impair adhesion of glazing materials.

C. Seal porous glazing channels or recesses with substrate compatible primer or sealer. Prime surfaces scheduled to receive glazing compound.

D. Do not perform glazing when ambient temperature is below 40 degrees Fahrenheit or during damp or rainy weather.

3.02 GLAZING

A. General Glazing Requirements:

1. Comply with applicable provisions of GANA Glazing Manual and the California Building Code, Table 2403.2.1, for minimum glazing requirements, and assure that minimum frame lap (minimum grip of glass) and edge clearances are provided as required for sizes of openings. Provide for expansion and contraction of glass as required.

2. Conform with manufacturers' latest published installation instructions and recommendations for glazing of tempered glass, wired glass, laminated glass, and insulating glass. Follow manufacturers' latest published instructions for protection of edges and sizing of glass.

3. Install glass in fire-rated assemblies in accordance with applicable requirements of NFPA 80.

4. Provide setting blocks at quarter points along bottom of glass pane. Blocks shall support glass not less than 1/16 inch above metal. Provide spacers to hold glass in center between stops.

B. Glazing of Hollow Metal Doors and Frames: Glass shall be set around all edges with glazing gaskets hereinbefore specified. Provide setting blocks and spacer blocks as required. Set gasket legs on both sides of glass. Gasket shall be continuous, notched only at top rail in the center. Compress gaskets at least 15 percent to form a tight seal.

C. Glazing of Metal Windows with Compound:

1. Face Glazing: Glass shall be glazed around all edges and exterior face of glass with glazing compound hereinbefore specified. Provide setting blocks and glazing clips as required. Clean surfaces to be glazed with solvent. Apply and compress glazing compound; smooth out and point with putty knife at 30-degree to 45-degree angle. Finished surfaces shall be uniformly smooth at required angle, mitered at corners.

2. Channel Glazing: Install glass of type indicated. Provide setting blocks, spacers, and accessories as required. Install glass in full bed of glazing compound and secure with stops, as required. No metal shall touch glass. Strike surplus compound smoothly from both sides of glass. Do not undercut compound.

3.03 CLEANING AND REPLACEMENT

A. Upon completion of glazing, remove paint spots, spatters, and other blemishes from glass.

B. Assure that each light is identified as to type and grade of glass.

C. Remove and replace glass panes that are cracked or broken and where distortion is evident and distracting, as determined by the Engineer.

D. Remove paper labels, wash, and polish glass just before acceptance by the Engineer.

E. Protect glass against damage from subsequent construction activities and vandalism.

END OF SECTION 08 80 00

SECTION 08 90 00

LOUVERS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Steel louvers.

B. Aluminum louvers.

1.02 RELATED SECTIONS

A. Section 07 60 00, Flashing and Sheet Metal.

B. Section 07 90 00, Joint Protection.

C. Section 09 24 11, Portland Cement Plaster.

D. Section 09 91 00, Painting.

1.03 MEASUREMENT AND PAYMENT

A. General: Louvers and vents will not be measured separately for payment but will be paid for as part of the Contract lump-sum price for Architectural Work.

1.04 REFERENCES

A. American Architectural Manufacturers Association (AAMA):

1. AAMA 2605 Voluntary Specifications, Performance Requirements and Test Procedures for Superior Performing Organic Coatings on Aluminum Extrusions and Panels

1.05 INTERFACE AND COORDINATION

A. Coordinate the Work of this Section with mechanical Work as required for providing combustion-air, air intake, and exhaust louvers for mechanical equipment.

1.06 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit fully detailed Shop Drawings of louvers showing fabrication and installation details.

C. Product Data: Submit manufacturer's performance data for louvers information on materials and fabrication, coating and colors, and installation instructions.

D. Samples: Where louvers are indicated to be factory finished, submit manufacturer's standard color chips for selection of color and texture by the Engineer.

1.07 QUALITY ASSURANCE

A. Design Criteria: Structural supports for louvers and vents shall be designed by the manufacturer to withstand a positive and negative wind load of 30 pounds minimum per square foot.

PART 2 – PRODUCTS

2.01 STEEL LOUVERS

A. Louver Type: Louvers shall be heavy-duty type, manufactured of 16 gauge galvanized steel, of size, section profile, and configuration indicated, four inches deep. Include the furnishing of all accessories, frame, sill, anchors, and fasteners as required for a complete installation.

B. Prime Coat: Louvers shall be bonderized and prime painted with a baked-on epoxy-based resin, corrosion-inhibitive metal primer in accordance with Section 09 91 00, Painting.

C. Bird Screen: Manufacturer's standard 1/2 inch wire mesh galvanized steel bird screen, mounted in removable frame and finished as specified for louvers.

D. Fasteners: Stainless steel or other appropriate tempered steel treated with non-corrodible material as approved by the Engineer.

2.02 ALUMINUM LOUVERS

A. Louver Type: Louvers shall be heavy-duty type, manufactured of 14 gauge aluminum, of size, section profile, and configuration indicated, 4 inches deep. Include the furnishing of all accessories, frame, sill, anchors, and fasteners as required for a complete installation.

B. Baked-Enamel Finish: All exposed aluminum surfaces shall be finished after fabrication with a satin finish, 70 percent fluoropolymer thermo-setting baked coating system which meets or exceeds the requirements of AAMA 2605. Minimum thickness shall be 1 mil. Color shall be as selected by the Engineer from manufacturer's standard color chart.

C. Bird Screen: Manufacturer's standard 1/2 inch mesh aluminum bird screen, mounted in removable frame and finished as specified for louvers.

D. Fasteners: Stainless steel, tempered aluminum, or other appropriate tempered steel treated with non-corrodible material as approved by the Engineer.

PART 3 – EXECUTION

3.01 PREPARATION

A. Check site dimensions affecting this work. Ensure openings affecting this work are properly prepared and that flashings are correctly located to divert moisture to the exterior.

3.02 INSTALLATION

A. Louvers, including bird screen and accessories, shall be installed as indicated and in accordance with the approved Shop Drawings and the louver manufacturer's installation instructions and recommendations.

B. Louvers shall be completely caulked and sealed around their perimeters with sealant and tape in accordance with Section 07 90 00, Joint Protection.

C. Exterior louvers and vents, at completion of installation, shall provide rainproof, leakproof service in accordance with Section 07 60 00, Flashing and Sheet Metal.

END OF SECTION 08 90 00

SECTION 09 01 36

TILE REPLACEMENT AND RESTORATION

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Removal of existing tile.

B. Cleaning of tile and grout.

C. Installation of new tile.

1.02 RELATED SECTIONS

A. Porcelain stone, ceramic and quarry tiles are specified in Section 09 30 00, Tiling.

1.03 DESCRIPTION

A. The station or building involved in this work will be in continuous operation during the construction period. This will require that the Contractor plan the Work carefully to work around unavoidable obstacles in the prosecution of the Work. It will require further that the Contractor complete some new construction facilities required in the renovation work before proceeding with the tile restoration and replacement work.

B. Provide such additional temporary facilities as may be required to facilitate continuous, unobstructed station or building operation during transitional construction work.

1.04 MEASUREMENT AND PAYMENT

A. General: Tile restoration and replacement will not be measured separately for payment but will be paid for as part of the Contract lump-sum price for Architectural Work.

1.05 REFERENCES

A. Comply with the Referenced Standards specified in Section 09 30 00, Tiling, as applicable to the tile restoration and replacement work. Include the following additional standard:

1. American National Standards Institute (ANSI):

    a. ANSI A108/A118/A136.1 Installation of Ceramic Tile

1.06 SUBMITTALS

A. Provide submittals in accordance with the requirements of Section 09 30 00, Tiling, as applicable to the tile restoration and replacement work, for the Engineer's view.

1.07 QUALITY ASSURANCE

A. Tile restoration and replacement work shall conform with the installation instructions and recommendations of the manufacturer of the ceramic and quarry tiles to be provided for this work.

B. Quality assurance for the tile restoration and replacement work shall conform with the quality assurance requirements of Section 09 30 00, Tiling, as applicable.

1.08 FIELD MOCK-UP

A. Provide field mock-up where large panels of new tile are involved requiring color and texture selection. Conform with requirements of Section 09 30 00, Tiling, as applicable to this work.

1.09 PRODUCT DELIVERY AND STORAGE

A. Comply with applicable requirements of Section 09 30 00, Tiling.

1.10 JOB CONDITIONS

A. Comply with applicable requirements of Section 09 30 00, Tiling.

1.11 MAINTENANCE MATERIALS

A. Comply with applicable requirements of Section 09 30 00, Tiling.

PART 2 – PRODUCTS

2.01 MATERIALS, EQUIPMENT, AND FACILITIES

A. Provide all materials, equipment, tools, appurtenances, facilities, and services as required for performing and completing the tile restoration and replacement work as indicated.

B. Where new materials and accessories are required to complete the tile restoration work as indicated, such new materials and accessories shall conform with the requirements of Section 09 30 00, Tiling, as applicable to the work.

C. Where removal of existing tile damages existing substrate, replace such damaged substrate with a ANSI A108/A118/A136.1 cementitious tile backer board. If damaged substrate is metal lath and cement plaster, conform with applicable requirements of Section 09 24 11, Portland Cement Plaster.

PART 3 – EXECUTION

3.01 EXAMINATION AND PREPARATION

A. Carefully remove existing tile, where indicated, with proper tools and methods. Include remove of existing setting beds.

B. After removal of existing tile, examine existing substrate surfaces and related framing for damage. Damaged or defective substrate surfaces and framing shall be repaired or replaced as required to provide substantial framed substrate surfaces conducive to the installation of new tile and trim shapes and as required to produce superior quality work.

C. Where the substrate is concrete or concrete block, chip off existing mortar setting bed, and then power wire brush to remove all loose particles and to provide clean, solid backing surface for new tile. Wash clean all substrate surfaces before application of new tile.

D. Verify that the work of other trades, to be in or behind new tile, is properly installed before proceeding with tile work.

E. Seal around all openings in floors and walls, at junction of floors and walls, and in corners and joints with sealant before installing new tile.

3.02 INSTALLATION STANDARDS

A. Comply with requirements specified in Section 09 30 00, Tiling, as applicable to this work.

3.03 INSTALLATION AND GROUTING

A. Comply with requirements specified in Section 09 30 00, Tiling, as applicable to this work.

B. Clean existing tile to remain, and point all grouted joints as required to fill all skips and gaps. Wash all tile and grouted joints, and polish tile upon completion.

3.04 TOLERANCES AND QUALITY CONTROL

A. Comply with the requirements specified in Section 09 30 00, Tiling, for tolerances and field quality control as applicable to this work.

3.05 CLEANING AND PROTECTION

A. Comply with the requirements specified in Section 09 30 00, Tiling, for cleaning of tile and for protection of completed work as applicable to this work.

END OF SECTION 09 01 36

SECTION 09 22 00

SUPPORTS FOR PLASTER AND GYPSUM BOARD

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Metal stud system.

B. Ceiling suspension system.

C. Metal furring.

1.02 RELATED SECTIONS

A. Cold-formed lightgage metal structural framing (16 and 18 gage studs and joists) is specified in Section 05 40 00, Cold-Formed Metal Framing.

B. Gypsum wallboard is specified in Section 09 29 00, Gypsum Board.

1.03 MEASUREMENT AND PAYMENT

A. General: Metal support systems for gypsum drywall construction will not be measured separately for payment but will be paid for as part of the Contract lump sum price for Architectural Work.

1.04 REFERENCES

A. American Society of Civil Engineers (ASCE):

1. ASCE 7 Minimum Design Loads for Buildings and Other Structures

B. American Society for Testing and Materials (ASTM):

1. ASTM C645 Standard Specification for Nonstructural Steel Framing Members

2. ASTM C754 Standard Specification for Installation of Steel Framing Members to Receive Screw-Attached Gypsum Panel Products

3. ASTM C1002 Standard Specification for Steel Self-Piercing Tapping Screws for Application of Gypsum Panel Products or Metal Plaster Bases to Wood Studs or Steel Studs

1.05 REGULATORY REQUIREMENTS

A. In addition to the foregoing referenced standards, the regulatory requirements which govern the work of this Section include the following governing code:

1. California Code of Regulations (CCR), Title 24, Part 2, California Building Code, Chapters 25, “Gypsum Board, Gypsum Panel Products and Plaster.”

1.06 SUBMITTALS

A. Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Submit manufacturer’s product data for ceiling suspension systems, including details of seismic bracing.

1.07 QUALITY ASSURANCE

A. Installation: Comply with the applicable requirements of ASTM C754.

B. Deflection: Unless otherwise indicated, allowable design deflection shall be L/360, based on requirements of ASCE 7.

PART 2 – PRODUCTS

2.01 METAL STUD SYSTEM

A. Studs: Typically 20 gage, 22 gage, and 25 gage as indicated, galvanized punched “C” or channel studs, of sizes indicated, conforming to ASTM C645. Furnish studs with punch-outs for pipes and conduits and with provision for interlocking a 1-1/2 inch reinforcing channel. Furnish bridging, extension splice plates, and channel reinforcing as required for a complete installation.

B. Floor and Ceiling Tracks: Unpunched channels of the same size and type as required for the studs installed therein, and of the same metal gage as studs.

C. Bolts: 1/4-inch diameter galvanized steel machine bolts. Provide galvanized washers for bolt heads and nuts.

D. Powder-Driven Fasteners: Low-velocity powder-driven fasteners, 1/4-inch or 3/8-inch diameter, with penetration of 3/4 inch, may be used for attaching floor and ceiling tracks in lieu of anchor bolts. Use washers with all inserts. Powder-driven fasteners will not be permitted for use on concrete curbs, at rough openings, along the edge of concrete or a concrete joint, or for penetrating metal decking.

E. Expansion Bolts: Galvanized expansion type anchors with matching galvanized bolts, minimum 1/4-inch diameter, may be used for attaching floor and ceiling tracks in lieu of anchor bolts. Use washers under all bolt heads and nuts. Expansion bolts

shall be located at least four inches from the edges or corners of concrete. Use of expansion bolts requires prior approval of the Engineer.

F. Screws: Screws for securing splice plates to studs and stud legs to tracks and at other locations as required shall be Phillips-head, Type S, contoured, self-drilling, self-tapping, steel drywall screws, conforming to ASTM C1002, of required lengths.

G. Backing Plates: Minimum 16 gage galvanized steel, four inches or more in height, and in lengths as required to span two or more stud spacings.

H. Sealant: Provide interior sealant for floor and ceiling track beads at acoustical walls and partitions and other locations where indicated, meeting requirements specified in Section 07 90 00, Joint Protection, for the location.

I. Miscellaneous Items: Provide such miscellaneous components, channels, angles, bracing, hangers, and wire as required to complete the installation. Include proper type cell or flute closures for metal decking where partitions extend to underside of floor or roof decking above.

2.02 CEILING SUSPENSION SYSTEM

A. Field-Fabricated Ceiling Suspension System:

1. Carrying Channels: Standard structural steel channels, hot-dipped galvanized, typically 1-1/2 inch section with flanges not less than 7/16-inch wide, weighing not less than 486 pounds per 1000 linear feet.

2. Hanger Wires: Soft steel wire not less than 0.1620-inch nominal diameter (eight or nine gage) with Class 2 zinc coating.

3. Turnbuckles: Zinc-coated steel or wrought iron turnbuckles with hook and hook-end pulls.

4. Furring Channels: 25 gage, electro-galvanized, roll-formed steel, hat- or trough-shaped channels, 7/8-inch deep, conforming to ASTM C645.

5. Clips: Standard product of the gypsum board manufacturer, manufactured specifically for the purpose of fastening furring channels to carrying channels, of size required for size of carrying channels.

B. Manufactured Ceiling Suspension System: The Contractor may provide a proprietary manufactured ceiling suspension system meeting indicated requirements, furnished complete with all components, anchors, fasteners, and accessories as required for a complete and finished installation.

2.03 METAL FURRING

A. 25 gage, electro-galvanized, standard drywall furring channels, hat- or trough-shaped furring channels, or z-furring channels, as indicated or required, conforming to ASTM C645.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Installation Standards: For details not indicated, comply with applicable requirements of the California Building Code, Chapter 25, and ASTM C754.

B. Metal Stud Systems:

1. Provide tracks as continuous top and bottom supports and anchors for all studs. Apply two parallel continuous beads of acoustical sealant under each floor and ceiling track at sound-insulated partitions.

2. Install powder-driven fasteners in accordance with the fastener manufacturer's installation instructions and recommendations. Maximum penetration in post-tensioned slabs: Three-fourth inch.

3. Install expansion bolts, where approved for use, in snug-fitting, smoothly drilled holes in accordance with the expansion-bolt manufacturer's installation instructions and recommendations. Anchors require specific acceptance by the Engineer before they may be used in post-tensioned slabs.

4. Locate and align floor tracks accurately. Secure to floor with anchor bolts, powder-driven fasteners, or expansion bolts at 24 inches on centers and not less than 6 inches from ends of each piece of floor track. Install anchors with washers.

5. Align ceiling tracks accurately by plumbing up from floor tracks. Fasten to structure above as specified for floor tracks for concrete or metal-deck soffits or as required by the type of construction. Provide bracing as required when tracks parallel ceiling furring channels.

6. Install metal studs in floor and ceiling tracks at a maximum spacing of 24 inches on center, unless indicated otherwise, and attach to tracks with screws or appropriate clips. Spliced studs will not be permitted.

7. Provide bridging between all studs as recommended by the manufacturer and as required by applicable codes.

8. Frame door jambs with two nested channel studs or 16 gage steel studs as specified in Section 05 40 00, Cold-Formed Metal Framing. Install reinforcing channels above headers, carried to the second stud past each jamb member. Carry jamb members full height to structure above, unless indicated otherwise.

9. Install backing plates and reinforcing of the various types indicated or required for the mounting of all items on or in partitions, walls, or shafts. Exact position of backing work shall be as designated by the trade whose work will be fastened thereto. The end result shall be that all items attached to or in gypsum board surfaces shall be firmly and solidly mounted.

10. Frame all openings in partitions with stud sections or sills and header members. Secure stud sections or sills and header members, by screws, bolts, rivets, or welding as required.

11. Provide any miscellaneous steel sections indicated or required to complete the Work.

12. Erection technique shall result in plumb and straight walls with no waves or buckles or unevenness at joints. Finished walls shall be flat within plus or minus 1/8 inch in 8 feet when checked in any direction with an eight-foot straightedge and plumb to within plus or minus one eight inch.

C. Ceiling Suspension System, Field Fabricated or Manufactured System:

1. Install ceiling suspension system, hanger wires, carrying channels, and furring channels, as indicated and in accordance with the component manufacturer's installation instructions and detail drawings.

2. Unless otherwise indicated, maximum spacing for hanger wires and carrying channels shall be four feet on centers.

3. Fasten hanger wires securely to the structure above with proper anchors as recommended by the suspension system components' manufacturer and as required to meet applicable code requirements.

4. Locate main runners (carrying channels) within 6 inches of parallel walls and cut them short of abutting walls one half inch.

5. Space furring channels 24 inches on center, unless indicated otherwise. Fasten furring channels to main runners with clips manufactured for the purpose.

6. Provide support bracing, diagonal bracing, reinforcing, anchors and fasteners, channels, and any other miscellaneous components as indicated or required for a complete installation and as necessary to meet seismic requirements.

7. At completion, ceiling systems shall be level in all directions within plus or minus one eighth inch when checked with a transit or water level.

D. Furring on Concrete and Masonry: Fasten hat-shaped or Z-type drywall furring channels securely to concrete and masonry with concrete nails, powder-driven fasteners, or expansion bolts in accordance with the drywall material manufacturer's instructions and recommendations. Concrete nails shall penetrate concrete a minimum of one inch. Nails, fasteners, or expansion bolts shall be installed with washers.

END OF SECTION 09 22 00

SECTION 09 24 11

PORTLAND CEMENT PLASTER

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Building paper.

B. Lath.

C. Exterior cement plaster (stucco).

1.02 RELATED SECTIONS

A. Ceramic tilework specified in Section 09 30 00, Tiling.

1.03 MEASUREMENT AND PAYMENT

A. General: Portland cement plaster work will not be measured separately for payment but will be paid for as part of the Contract lump sum price for Architectural Work.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM A653/A653M Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
2. ASTM B69 Specification for Rolled Zinc
3. ASTM C150 Specification for Portland Cement
4. ASTM C206 Specification for Finishing Hydrated Lime
5. ASTM C847 Specification for Metal Lath
6. ASTM C897 Specification for Aggregate for Job-Mixed Portland Cement-Based Plasters
7. ASTM C926 Specification for Application of Portland Cement-Based Plaster
8. ASTM C932 Specification for Surface-Applied Bonding Agents for Exterior Plastering
9. ASTM C954 Specification for Steel Drill Screws for the Application of Gypsum Board or Metal Plaster Bases to Steel Studs from 0.033 in. (0.84 mm) to 0.112 in. (2.84 mm) in Thickness

10. ASTM C1002 Specification for Steel Drill Screws for the Application of Gypsum Board or Metal Plaster Bases

B. International Conference of Building Officials, Uniform Building Code (UBC):

1. UBC Std. 14-1 Kraft Waterproof Building Paper

1.05 REGULATORY REQUIREMENTS

A. In addition to the foregoing referenced standards, the regulatory requirements that govern the work of this Section include the following governing code:

California Code of Regulations (CCR), Title 24, Part 2, California Building Code, Chapters 14 and 14A, “Exterior Wall Coverings,” and Chapters 25 and 25A, “Gypsum Board and Plaster.”

1.06 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit Shop Drawings showing locations of all expansion and control joints in elevation and details of such joints.

C. Product Data: Submit manufacturer's product data to accompany each manufactured item that requires a sample to be submitted.

D. Samples:

1. Submit 12-inch-long samples of each type of lath, expansion and control joint, weep screed, corner bead, and other metal accessories to be used in the work.

2. Submit 8-inch by 10-inch sample panel of proposed cement plaster finish.

1.07 DELIVERY AND STORAGE OF MATERIALS

A. Deliver manufactured materials in their original packages and containers, bearing name of manufacturer and brand. Store cement, plaster, and lime in assigned room or area and away from damp surfaces. Remove damaged or deteriorated materials from the site.

1.08 PROTECTION

A. Protect surfaces adjacent to plastering work from spattering or other staining caused by plastering. Surfaces so spattered or stained shall be cleaned to the satisfaction of the Engineer within 24 hours of application.

B. Protect plaster work from subsequent construction and finishing activities, and maintain protection until acceptance of the work by the Engineer.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Building Paper: At exterior walls and soffits, provide "breathable" weather-resistive barriers as required by the California Building Code, Chapter 14A, Section 1402A.1, conforming with UBC Std. 14-1, Grade D building paper.

B. Lath:

1. Stucco Netting: Standard No. 18 gage, one inch hexagonal mesh, galvanized stucco lath, self-furring. Plain stucco netting may be used over sheathing and building paper with the use of 1/4-inch furring washers.

2. Expanded Metal Lath: ASTM C847, diamond mesh, expanded copper-bearing steel, galvanized, weighing 3.4 pounds per square yard, self-furring.

C. Lathing Accessories:

1. Provide corner reinforcement, base, drip, and weep screeds, strip lath, control and expansion joints, soffit vents, and any other accessories indicated or required to complete the installation. Lathing accessories shall be standard manufactured products, manufactured specifically for the purpose.

2. Lathing accessories for exterior cement plaster shall be fabricated from zinc sheet conforming to ASTM B69.

3. Lathing accessories for interior cement plaster shall be fabricated from galvanized steel sheet conforming to ASTM A653/A653M.

4. Control and expansion joints shall be provided with removable tape to prevent plaster from filling the joint.

D. Lath Tie Wire: No. 18 gage galvanized soft steel wire.

E. Lath Fastenings: Self-drilling, self-tapping, steel screws, conforming to ASTM C954 or ASTM C1002, as applicable for type of metal framing, of required lengths. Include metal washers for engaging lath and furring washers for spacing stucco netting 1/4 inch from sheathing board or metal framing as applicable.

F. Portland Cement: ASTM C150, Type II, low alkali.

G. Aggregate: ASTM C897.

H. Lime: ASTM C206.

I. Water: Fresh, clean and potable, and free from such amounts of mineral and organic substances as would adversely affect the hardening and strength of cement plaster.

J. Exterior Cement Plaster (Stucco) Finish Coat: Cement-lime cement plaster (stucco) finish coat or an approved manufacturer's prepared premixed cement plaster (stucco) finish coat, meeting requirements of ASTM C926, for stucco, in sandfloat finish. Exact texture shall be as selected and approved by the Engineer from samples prepared and submitted by the Contractor.

K. Fiber Reinforcement: Chopped strands of alkali-resistant polypropylene fiber, 1/2-inch long, for use in scratch coat only.

L. Bonding Agent: ASTM C932, for bonding of cement plaster to concrete or masonry substrate.

PART 3 – EXECUTION

3.01 APPLICATION OF BUILDING PAPER

A. Apply building paper, before lathing, over all exterior sheathing board for surfaces to receive cement plaster (stucco) in compliance with the California Building Code, Chapter 14, Section 1402, Chapter 14A, Section 1402A, Chapter 25, Section 2506 and Chapter 25A, Section 2506A. Apply building paper over sheathing in two separate layers or plies, as follows:

1. Apply first layer over sheathing horizontally, lapping sides 2 inches to weather and 6 inches at ends. Secure sufficiently with staples, or other acceptable fasteners, to hold in place without sagging until second layer is applied.

2. Apply second layer over first layer, again horizontally, lapping sides 6 inches to weather and ends 6 inches. Secure sufficiently with staples to hold in place without sagging until lath is applied. Horizontal joints of second layer shall not occur directly over horizontal joints of first layer.

3.02 APPLICATION OF LATH

A. Apply stucco lath directly over sheathing and framing members with screws specified, spaced not more than 6 inches apart vertically and 16 inches apart horizontally, directly over framing members. Screws shall engage the lath securely with washers as required. Laps of stucco lath shall be 1 inch minimum and shall be laced with 18 gage galvanized soft steel wire. If plain or standard stucco netting is used, apply in same manner, except that fasteners shall include furring washers.

B. At soffits, use 3.4 pound galvanized expanded metal lath, reinforced with standard 18 gage stucco netting applied over the expanded lath with screws and furring washers. Apply expanded metal lath directly over building paper and sheathing, and then apply stucco netting directly over expanded metal lath, fastening both securely 6 inches on center directly to framing (through sheathing). All laps shall be securely laced with tie wire.

C. Install all required plaster grounds, base, drip, and weep screeds, corner reinforcement, special stops, control joints, strip lath, soffit vents, and other metal

accessories. Apply and shim out to required thickness. Set plumb, level and straight, free of kinks and bends. Install casing beads or stops at edges of plaster continuously. Provide expansion joints where indicated. Provide control joints where indicated, or if not indicated, in accordance with the following requirements:

1. Where dissimilar substrate materials meet, such as concrete or concrete block and metal studs.

2. In line with control joints in masonry substrate.

3. Above and in-line with door jambs.

4. In any wall or ceiling area bounded by expansion or control joints otherwise required, provide control joints on a regular pattern so that the total area bounded by control or expansion joints does not exceed 100 square feet.

5. Obtain the Engineer's approval of locations before installing control joints.

D. Make intersections and splices of lathing accessories in accordance with manufacturer's instructions. When horizontal and vertical expansion and control joints meet, make the vertical joint unbroken.

E. Break lath behind expansion and control joints. Do not fasten opposite sides of expansion and control joints to a monolithic backing material. Where cement plaster is backed by studs, provide a stud on either side of the joint.

3.03 APPLICATION OF EXTERIOR CEMENT PLASTER (STUCCO)

A. General Requirements:

1. Exterior cement plaster shall be applied in three-coat work to a minimum thickness of 7/8 inch, and shall be finished in texture matching the approved sample or job mockup.

2. Scratch coat ingredients shall include glass fiber or polypropylene fiber reinforcement at the rate of 1-1/2 to 2 pounds per 94 pound bag of cement.

3. Proportions of portland cement, lime, and aggregate shall be within the limits specified in ASTM C926.

B. Application:

1. Scratch Coat: Scratch coat shall be applied to minimum thickness of 3/8 inch, completely embedding the lath. Scratch coat shall be scratched horizontally to provide mechanical key, and properly cured before applying brown coat.

2. Brown Coat: Brown coat shall be applied to minimum thickness of 3/8 inch in two applications and shall be brought to a true, even plane by rodding and floating, and shall be left rough and ready to receive the finish coat. Scratch coat shall be dampened to provide suction before applying brown coat. Brown coat shall be properly cured before applying finish coat.

3. Finish Coat: Finish coat shall be laid out to permit the completion of an entire surface in one operation. Finish coat shall be applied to minimum thickness of 1/8 inch, or in such thickness as may be necessary to ensure the full thickness specified. Brown coat shall be dampened evenly to provide suction before applying finish coat.

C. Application Over Concrete or Masonry: Where cement plaster is to be applied directly over concrete or masonry, only brown coat and finish coat are required. Substrate surfaces shall be roughened as necessary and cleaned, and a bonding agent shall be applied, in accordance with manufacturer's instructions, before applying the brown coat.

3.04 WORK QUALITY

A. Finished surfaces shall be uniform as to texture and color throughout the area. Intersections of planes shall be sharp and accurate. Plane surfaces shall be finished plumb, straight, and true to plus or minus 1/8 inch when tested with an 8-foot straightedge.

B. Where plaster stops, screeds, control or expansion joints, angles, wall panels, or other features are employed for architectural treatment, panels framed by these accessories or other construction shall be finished in one operation. No stopping vertically or horizontally in the middle or intermediate area of a panel will be permitted.

C. Imperfections that occur after curing and drying shall be properly repaired.

3.05 CURING AND PROTECTION OF PLASTER

A. Comply with applicable requirements of ASTM C926. Each coat of cement plaster shall be moist cured by application of fine fog spray for a minimum period of four days. Moistening shall begin as soon as the plaster has hardened sufficiently. Soaking of walls shall be avoided.

B. Apply only as much water as will be readily absorbed. Protect plaster from uneven and excessive evaporation during hot, dry weather. Provide for curing of plaster on Saturdays, Sundays, and holidays, if necessary.

C. Protect cement plaster against damage from cold or too rapid drying or from any other cause.

END OF SECTION 09 24 11

SECTION 09 29 00

GYPSUM BOARD

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Gypsum wall board.

B. Fire-rated board.

C. Water-resistant (W/R) backing board.

D. Joint compound and tape.

E. Accessories.

F. Screws.

G. Sealant.

1.02 RELATED SECTION

A. Cementitious backer board for ceramic tile is specified in Section 09 30 00, Tiling.

1.03 MEASUREMENT AND PAYMENT

A. General: Gypsum drywall construction will not be measured separately for payment but will be paid for as part of the Contract lump sum price for Architectural Work.

1.04 DESCRIPTION

A. When a fire resistance rating is indicated for a gypsum board assembly, details of construction shall be in accordance with reports of fire tests of assemblies which have met the requirements of the indicated fire rating.

B. When a sound transmission class (STC) rating is indicated for a gypsum board assembly, details of construction shall be in accordance with reports of acoustical tests of assemblies which have met the requirements of the indicated acoustical rating.

C. Details of construction not specified herein shall conform to applicable requirements of ASTM C840.

1.05 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM C11	Standard Terminology Relating to Gypsum and Related Building Materials and Systems
2. ASTM C473	Standard Test Methods for Methods for Physical Testing of Gypsum Panel Products
3. ASTM C475/C475M	Standard Specification for Joint Compound and Joint Tape for Finishing Gypsum Board
4. ASTM C840	Standard Specification for Application and Finishing of Gypsum Board
5. ASTM C919	Standard Practice for Use of Sealants in Acoustical Applications
6. ASTM C954	Standard Specification for Steel Drill Screws for the Application of Gypsum Panel Products or Metal Plaster Bases to Steel Studs from 0.033 in. (0.84 mm) to 0.112 in. (2.84 mm) in Thickness
7. ASTM C1002	Standard Specification for Steel Self-Piercing Tapping Screws for the Application of Gypsum Panel Products or Metal Plaster Bases to Wood Studs or Steel Studs
8. ASTM C1047	Standard Specification for Accessories for Gypsum Wallboard and Gypsum Veneer Base
9. ASTM C1396/C1396M	Standard Specification for Gypsum Board
10. ASTM E119	Standard Test Methods for Fire Tests of Building Construction and Materials
11. ASTM E596	Standard Test Method of Laboratory Measurement of Noise Reduction of Sound-Isolation Enclosures
12. ASTM E1704	Standard Guide for Specifying Acoustical Performance of Sound-Isolating Enclosures

1.06 REGULATORY REQUIREMENTS

A. In addition to the foregoing referenced standards, the regulatory requirements which govern the work of this Section include the following governing code:

1. California Code of Regulations (CCR), Title 24, Part 2, California Building Code, Chapters 25, “Gypsum Board, Gypsum Panel Products and Plaster.”

1.07 DEFINITIONS

A. Words and terms used in this Section and not defined herein shall be interpreted in accordance with the definitions given in ASTM C11.

1.08 QUALITY ASSURANCE

A. Qualifications: Company performing gypsum board installation shall have minimum 5 years documented experience and company furnishing gypsum board shall be able to supply complete and tested systems conforming to code.

B. Mock-Up: Before beginning gypsum board installation, install at least 100 square feet in surface area mockups of gypsum board finish and control joints to demonstrate aesthetic effects and set quality standards for materials and execution.

1. Apply or install final decoration indicated, including painting and wallcoverings, on exposed surfaces for review of mockups.

2. Simulate finished lighting conditions for review of mockups.

3. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

4. Approved mock-ups may be incorporated into Work and become standard for approved workmanship and finishes.

1.09 JOBSITE CONDITIONS

A. Maintain room temperature of not less than 40 degrees Fahrenheit during application of gypsum board, and 50 degrees Fahrenheit during application of joint treatment and for 48 hours thereafter. If temporary heat is provided, do not allow the temperature to exceed 95 degrees Fahrenheit.

B. Maintain adequate ventilation in the working area during installation and finishing.

1.10 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to the Jobsite and store them in the work area if possible, so that materials will have a minimum period of 24-hours storage at the same temperature as the installation area.

B. Store gypsum board in the horizontal position. When necessary to stack palettes, align blocking vertically to avoid distortion of boards.

C. Handle gypsum board with caution when stacking. Use care when loading by two or more people. Do not drag materials.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Board Physical Properties: Refer to indicated details and notes on the Contract Drawings for type and thickness of board. Where thickness is not indicated, provide 5/8-inch-thick board.

B. Gypsum Wallboard: ASTM C1396/C1396M, furnished with tapered longitudinal edges and in lengths which will result in a minimum footage of joints.

1. Provide foil-backed gypsum wallboard for interior facing of exterior walls where gypsum wallboard is scheduled for the interior finish and for gypsum wallboard furred over concrete or masonry.

C. Fire-Rated Board: Provide Type X board for assemblies indicated to have a fire-resistance rating.

D. Water-Resistant (W/R) Backing Board: ASTM C1396/C1396M, 5/8-inch thick. Provide Type X water-resistant gypsum backing board where water-resistant gypsum board walls and ceilings are indicated to have a fire-resistance rating.

E. Joint Compound and Tape: ASTM C475/C475M, joint tape, taping compound, and finishing compound. All-purposed compound may be substituted for taping compound and finishing compound.

F. Accessories: ASTM C1047, galvanized steel. Provide metal corner bead for all external corners and angles and metal edge trim at all junctions of gypsum wallboard and walls of other materials and for all exposed edges.

G. Screws: ASTM C954 or ASTM C1002, as applicable for type of metal framing, of required lengths.

H. Sealant: Sealant for holes or penetrations in acoustical and damp-service partitions shall conform to applicable requirements of Section 07 90 00, Joint Protection.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Apply gypsum wallboard in accordance with applicable requirements of ASTM C840.

B. Before applying gypsum board, verify that corners and framing are plumb, true, and solid. Apply no gypsum board until conduits, boxes, pipes, ducts, vents, supports, fixture frames, blocking and backing, and the like are in place and inspected, tested, and approved as required. All edges and ends of gypsum board shall have solid bearing.

C. Apply wallboard over metal framing and furring with self-drilling, self-tapping screws installed with an electric screw-gun equipped with adjustable screw depth control. Drive screw heads slightly below the surface of the wallboard, taking care to avoid breaking the paper face or fracturing the gypsum core. Space screws a maximum of 12 inches on center in the field of boards and eight inches on center staggered along the abutting edges for walls, and seven inches on center along abutting edges for ceilings. Do not drive screws closer than 3/8 inch from edges and ends.

D. Apply wallboard first to ceilings and then to walls, using maximum practical lengths to minimize end joints. End joints will not be permitted on walls or partitions less than 16 feet in height. Wallboard shall be applied vertically to walls. Joints on opposite sides of the same wall or partition shall occur on different studs. Boards shall be installed in moderate contact, not forced in place.

E. In two-ply gypsum board construction, apply the base ply perpendicular to framing members and the face ply parallel to framing members. Laminate face-ply to base-ply with adhesive or all-purpose compound. Fasten with a sufficient number of screws to hold the board in place until the laminating adhesive or compound has set, but not less than 12-inch spacing on ceilings and 16-inch spacing on walls. Joints in the face ply shall be offset from joints in the base ply by not less than 16 inches.

F. Provide metal corner bead at all vertical and horizontal external corners and angles. Provide metal edge trim at all junctions of gypsum wallboard and walls of other materials or where there are exposed edges.

G. At acoustical or sound walls, penetrations of walls shall have a minimum clearance of 1/4 inch along their perimeters at wallboard, that shall be filled with sealant. Fill all voids completely with sealant. Install wallboard 1/4 inch to 3/8 inch above floor and fill resultant space with sealant. Achieve maximum sound insulation through careful installation work in jointing, sealing, taping, and staggering of joints.

H. Gypsum wallboard surfaces shall have a maximum variation of 1/8 inch in eight feet when a straightedge is laid on the surface in any direction.

3.02 TAPING AND FINISHING

A. Tape and finish all joints, corners, metal accessories, screw heads, damaged or abraded surfaces, and cutouts for the work of other trades in accordance with ASTM C840 and the drywall materials manufacturer’s instructions and recommendations.

B. Joints, wall and ceiling angles, and inside vertical corners shall be reinforced with tape embedded in taping compound and finished with not less than two applications of finishing compound, allowing each application to dry thoroughly and sanding between coats as required. Dimples at screws heads and other imperfections shall be similarly treated.

C. External corners, edges, and ends with metal beads and edge trim shall have the flanges completely spackled and feathered off smooth from the nose.

D. Final application of finishing compound and sanding shall leave gypsum wallboard surfaces uniformly smooth and in proper condition to receive a painted finish.

E. Type X gypsum backing board shall be fire-taped as required.

END OF SECTION 09 29 00

SECTION 09 30 00

TILING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Tile.

B. Marble thresholds.

C. Setting bed and adhesive.

D. Grout.

E. Reinforcement.

F. Cleavage membrane.

G. Sealant.

H. Cementitious backer board.

I. Cementitious backer board accessories.

1.02 RELATED SECTIONS

A. Lath and portland-cement plaster backing (scratch coat) for wall tile applied over full mortar setting bed is specified in Section 09 24 11, Portland Cement Plaster.

B. Granite flooring is specified in Section 09 63 19, Stone Flooring.

1.03 MEASUREMENT AND PAYMENT

A. General: Ceramic and quarry tilework will not be measured separately for payment but will be paid for as part of the Contract lump sum price for Architectural Work.

1.04 REFERENCES

A. American National Standards Institute (ANSI):

1. ANSI A108.1B — Cement Tile Installed on a Cured Portland Cement Mortar Setting Bed with Dry-Set or Latex Portland Cement Mortar
2. ANSI A108.4 — Ceramic Tile Installed with Organic Epoxy Adhesive
3. ANSI A108.5 — Ceramic Tile Installed with Dry-Set or Latex-Portland Cement Mortar

4. ANSI A108.6 Ceramic Tile Installed with Chemical Epoxy Mortar and Grout
5. ANSI A108.10 Installation of Grout in Tilework
6. ANSI 108.11 Interior Installation of Cementitious Backer Units
7. ANSI A118.1 Dry-Set Portland Cement Mortar
8. ANSI A118.3 Chemical Resistant, Water Cleanable Tile-Setting and Grouting Epoxy and Water Cleanable Tile-Setting Epoxy Adhesive
9. ANSI A118.4 Latex-Portland Cement Mortar
10. ANSI A118.6 Standard Ceramic Tile Grouts for Tile Installation
11. ANSI A118.9 Cementitious Backer Units
12. ANSI A136.1 Organic Adhesives for Installation of Ceramic Tile
13. ANSI A137.1 Ceramic Tile

B. American Society for Testing and Materials (ASTM):

1. ASTM C144 Standard Specification for Aggregate for Masonry Mortar
2. ASTM C150/ C150M Standard Specification for Portland Cement
3. ASTM C207 Standard Specification for Hydrated Lime for Masonry Purposes
4. ASTM C920 Standard Specification for Elastomeric Joint Sealants
5. ASTM C1325 Standard Specification for Non-Asbestos Fiber-Mat Reinforced Cementitious Backer Units
6. ASTM D2178/ D2178M Standard Specification for Asphalt Glass Felt Used in Roofing and Waterproofing

C. The Tile Council of North America (TCNA):

1. TCNA Handbook for Ceramic, Glass, and Stone Tile Installation

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit fully detailed Shop Drawings, showing tile layouts, dimensions, bedding and joint details, and connections to adjoining work.

C. Product Data: Submit manufacturer's specifications, catalog cuts, color range of tile, data sheets, installation instructions, and maintenance instructions. Include certifications and other data to show compliance with Contract requirements.

D. Samples: Submit samples of each type, class, finish, and color of tile and grout, not less than 12 inches square, on plywood backing, with grouted joints as indicated. Include at least one complete grouted tile intersection. Samples shall show full range of color and texture. Samples shall match the Engineer's control samples. Samples require approval of the Engineer before they may be used in the work.

1.06 QUALITY ASSURANCE

A. Master Grade Certificates: Furnish a Master Grade Certificate as specified in ANSI A137.1 for each type of tile, signed by the manufacturer and the Contractor, certifying to the grade, type and quantity of tile, together with satisfactory information for identification of the containers to which they apply.

B. Control Samples: Tile shall match the Engineer's control samples in all respects. Control samples require the Engineer's approval before they may be used as a standard.

C. Single Source Responsibility: Obtain each material required for any one type and color of tilework from a single source to minimize variations in appearance and quality.

D. Installation Standards: Comply with TCNA Handbook for Ceramic Tile Installation and the herein referenced standards for all tile installations.

1.07 FIELD MOCK-UP

A. Requirements: Provide field mock-ups, as specified, for the Engineer's approval.

B. Typical Floor Panel: The Contractor shall install a typical floor panel, approximately 3-feet square in an appropriate location. Mock-up shall include joint treatment and other accessories as required for a finished installation. Keep panel damp until mortar has set; dry slowly to attain true appearance of finished work. Maintain accepted panel as the standard for completed work. Provide a typical floor panel for each different type of tile flooring and floor design indicated.

C. Typical Wall Panel: The Contractor shall install a typical wall panel, approximately 3 feet by 4 feet, in an appropriate location. Mock-up shall include joint treatment, trim shapes, wainscot cap when applicable, cove base, and other accessories as required for a finished installation. Keep panel damp until mortar has set; dry slowly to attain true appearance of finished work. Maintain accepted panel as the standard for completed work. Provide a typical wall panel for each different type of tile wall and wall design indicated.

D. Acceptance: Approved typical floor and wall panels will be used to establish acceptable minimum standards of appearance and work quality. Acceptance will be based on uniformity, color match, proper texture, and proper construction methods.

1.08 PRODUCT DELIVERY AND STORAGE

A. Deliver materials, other than bulk materials, in manufacturer's unopened containers, fully identified with name, brand, type, grade, class, size, color, and pattern. Store materials above ground and protect from weather and damage. Store in accordance with the respective manufacturer's instructions.

1.09 JOB CONDITIONS

A. Examine substrates and adjoining construction, and the conditions under which tilework is to be installed. Do not proceed with tilework until conditions detrimental to the proper and timely completion of this work have been corrected.

B. Allowable Variations in Substrate Levels:

1. For Full Mortar Setting Bed Floors: Plus or minus 1/4 inch in 10 feet in any direction and 3/8 inch total maximum variation from levels indicated.

2. For Full Mortar Setting Bed Walls: Plus or minus 1/8 inch in eight feet in any direction and 1/4 inch total maximum variation from indicated planes.

3. For Thin-Set Tilework: Substrate shall conform with the allowable variations in finished work as specified in Article 3.03 herein. Where floor drains occur, substrate shall have minimum slope of 1/8 inch per foot to drain.

C. Set tile and grout tile joints when ambient temperature is above 50 degrees Fahrenheit. Do not set or grout tile when ambient temperature is above 90 degrees Fahrenheit.

1.10 MAINTENANCE MATERIALS

A. Upon completion of the Work, deliver to the Engineer an additional two percent of total of each tile size, pattern, and color used on the job, for use in future repair and maintenance work. Furnish boxes of whole tiles, sealed and properly identified. Include trim shapes.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Tile: ANSI A137.1, Standard grade. Tile types, sizes, colors, and finishes shall be as indicated.

1. Floor Tile: Machine-made tiles including porcelain stone, natural clay-type ceramic, or quarry floor tile of sizes, thickness, colors, and textures indicated, matching the Engineer's control samples for the location.

2. Wall Tile and Base: Machine-made natural clay-type ceramic wall tile of sizes, thickness, colors, and textures indicated, matching the Engineer's control samples for the location. Provide cove base with straight top at floors where there is tile wall above and cove base with bullnose top at floors where there is no tile above.

3. Trim: Include matching stops, returns, trimmers, caps, and special shapes required to produce complete, neatly finished installation. Provide cove base at intersection of floors and walls. Tops of wainscots shall have bullnose shape.

B. Marble Thresholds: Saddle-type thresholds of profile and dimensions indicated, cut accurately to correct door-opening dimensions. Marble shall be a white or off-white, honed or polished marble appropriate for thresholds.

C. Setting Bed and Adhesive Materials:

1. Full-Thick Portland Cement Mortar Setting Bed:

   a. Portland Cement: ASTM C150/C150M, Type I.

   b. Lime: ASTM C207, Type S.

   c. Sand: ASTM C144.

   d. Water: Clean and potable.

   e. Proportions: In accordance with ANSI A108.1B.

   f. Bond Coat: ANSI A118.1 dry-set portland cement mortar or ANSI A118.4 latex portland cement mortar skim coat.

2. Thinset, Dry-Set Portland Cement Mortar: ANSI A118.1.

3. Thinset, Latex-Portland Cement Mortar: ANSI A118.4.

4. Epoxy Adhesive: ANSI A118.3.

5. Water-Resistant Organic Adhesive: ANSI A136.1. Water-resistant organic adhesive only shall be used for the application of wall tile over W/R gypsum board backing surfaces.

D. Grout: ANSI A118.6, colors as indicated. If indicated colors are not available from manufacturer's standard colors, custom colors shall be provided. If colors are not indicated, colors shall be as selected by the Engineer from manufacturer's standard colors.

E. Reinforcement: Two-inch by two-inch mesh, 16 gage galvanized steel wire fabric.

F. Cleavage Membrane: ASTM D2178/D2178M, asphalt-impregnated glass felt, Type III - standard ply sheet, with overlap of 4 inches minimum.

G. Sealant: Mildew-resistant urethane or silicone sealant conforming with applicable requirements of ASTM C920. Provide Grade P for joints in horizontal surfaces and Grade NS for joints in vertical surfaces. Provide for M and G uses. Sealant may be Type S or Type M as appropriate. Color shall match color of grouted joints. Include proper backer rod where indicated or required.

H. Cementitious Backer Board: ASTM C1325 or ANSI A118.9 for use as backing for tile.

I. Cementitious Backer Board Accessories:

1. Two-inch wide glass fiber mesh tape for use over cementitious backer board in ceramic tile installation.

2. Fasteners shall be non-corrosive and non-oxidizing.

PART 3 – EXECUTION

3.01 EXAMINATION OF SUBSTRATE SURFACES

A. Examine subfloor and substrate surfaces to receive tile. Subfloor and substrate surfaces shall be firm, dry, clean, and free from defects or irregularities that may impair bond or jeopardize the quality of the work, and no tile work shall be performed over affected areas until suitable corrections have been made.

B. Verify that work of other trades, in or behind the tile, is installed before proceeding with tilework.

C. Confirm that metal stud spacing and gage comply with ceramic tile installation requirements.

3.02 PREPARATION

A. Etch concrete and concrete block substrate with ten percent solution of muriatic acid as required to remove curing compounds or other substances that may interfere with proper bond of specified mortar for tile. Rinse clean with water to remove traces of acid.

B. Seal around all openings in floors and walls, at junctions of floors and walls, and in corners and joints with sealant before installing tile.

C. Install cementitious backer board in accordance with ANSI 108.11. Space horizontal and vertical joints and corners 1/8 inch and fill solid with dry-set or latex-portland cement mortar. Maximum variation in backing surface shall be 1/4 inch in 10 feet. Cementitious backer board shall be taped and finished smooth using glass fiber mesh tape embedded in a skim coat of mortar over joints and corners. Where waterproof membrane occurs, coordinate installation of cementitious backer board and waterproof membrane.

3.03 INSTALLATION STANDARDS

A. Comply with the TCNA Handbook for Ceramic Tile Installation methods specified in the Contract Specifications.

B. Comply also with ANSI A108.1B, A108.4, A108.5, A108.6, and A108.10 as applicable for the indicated installation.

C. Comply with manufacturer's instructions and recommendations for special requirements not covered by referenced standards.

3.04 INSTALLATION

A. Lay out tilework in patterns indicated using field tile and trim shapes as indicated or required. Center tile fields in both directions in each space or on each wall area, and adjust to minimize tile cutting. Provide uniform joint widths of 1/16 inch, unless otherwise indicated.

B. Cut field tile, not trim shapes, unless otherwise indicated.

1. Avoid cutting tile but, if necessary, use a power-operated abrasive saw. Finish cut edges of tile with a carborundum stone to match the uncut edges.

2. Tiles which are cut to permit the passage of another element through the finished surface are to fit it neatly around such penetration, not less than 3/8 inch nor more than 1/2 inch from such penetration. Make templates as required. Use power operated wetsaws, bandsaws, and core drills as required.

C. Tile floors shall be in true planes, sloped a minimum of 1/8 inch per foot to floor drains. Waves or depressions in floors will not be accepted. Tile walls shall be in true planes, plumb and level. Tile joints in floors and walls shall line up. Tile out of line or out of plane will not be accepted.

D. Extend tilework into recesses and under equipment and fixtures in the spaces indicated or scheduled to receive tile. Form a complete covering without interruptions. Terminate work neatly at obstructions, edges, and corners, without disruption of pattern or joint alignments.

E. Provide expansion joints in tilework where indicated. Provide sealant and backer rod as required. Joints shall coincide with building expansion joints where they occur, and shall penetrate the tile setting bed completely.

F. Install cleavage membrane over concrete or masonry surfaces where indicated or required.

G. Install metal reinforcement in full-thick mortar setting bed for floor tile where indicated or required.

3.05 GROUTING

A. Comply with applicable requirements of ANSI A108.10. Force a maximum of grout into all joints. Grouted joints shall be full and integral with setting bed. Before grout sets, strike or tool the joints of cushion-edge tile to depth of cushion, filling all gaps or skips, and with square-edge tile, fill joints flush with their surface, tooling joints smooth and dense.

3.06 TOLERANCES

A. The finished work shall not exceed the following deviations from level and plumb, and from elevations, locations, slopes, and alignments indicated:

1. Floors: One eighth inch in eight feet in any direction; plus or minus 1/8 inch at any location; 1/32 inch offset at any location.

2. Walls: One eighth inch in eight feet in any direction; plus or minus 1/8 inch at any location; 1/32 inch offset at any location.

3. Joints: Nominal 1/16-inch standard joint width, plus or minus 1/32-inch variation at any location; 1/16 inch in 8 feet for deviation from the plumb, and for other variations in alignment of joints.

3.07 FIELD QUALITY CONTROL

A. Provide quality control checks of completed tilework by tapping (or sounding) tile surfaces with a soft wood or rubber mallet to detect individual tiles which are not properly bedded or bonded.

3.08 CLEANING

A. After grout has set, sponge and wash tiles thoroughly and then polish with clean, dry cloths. Use no acids or abrasive soaps on tile, except as approved by the tile manufacturer. Tile having stains or discoloration that are not removable with soap and clean water shall be replaced.

B. In addition to the initial cleaning procedure required, and not more than two days before final acceptance of this work, provide a final cleaning and polishing of ceramic tilework as recommended by the tile manufacturer.

3.09 PROTECTION OF COMPLETED WORK

A. Close spaces in which tile is being set to traffic and other work; keep closed until firmly set. Protect from damage until Contract acceptance by the District. Before traffic is permitted on tile floors, cover floors with nonstaining building paper. Lay board walkways on floors that are to be used as passageways by workers. Remove cracked, broken or damaged tile; replace with new tile.

END OF SECTION 09 30 00

SECTION 09 51 13

ACOUSTICAL PANEL CEILINGS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Ceiling suspension system.

B. Acoustical ceiling panels.

C. Access system.

1.02 RELATED SECTIONS

A. Coordinate the work of this Section for above-ceiling ductwork and for ceiling-mounted air diffusers.

B. Coordinate the work of this Section with the work for above-ceiling electrical conduits and raceways and for ceiling-mounted lighting fixtures and speaker boxes.

1.03 MEASUREMENT AND PAYMENT

A. General: Acoustical panel suspended ceilings will not be measured separately for payment but will be paid for as part of the Contract lump sum price for Architectural Work.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM C635 Specification for the Manufacture, Performance, and Testing of Metal Suspension Systems for Acoustical Tile and Lay-In Panel Ceilings

2. ASTM C636 Practice for Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-In Panels

B. Federal Specifications (FS):

1. SS-S-118 Sound Controlling (Acoustical) Tiles and Panels

C. International Conference of Building Officials, Uniform Building Code (UBC):

1. UBC Std. 25-2 Metal Suspension Systems for Acoustical Tile and for Lay-in Panel Ceilings

1.05 QUALITY ASSURANCE

A. Seismic Design: Details of seismic bracing shall conform with UBC Standard No. 25-2, except as indicated otherwise.

1.06 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit manufacturer's details and specifications of the ceiling suspension system, including details of anchorage to the structure above and of seismic bracing.

C. Samples: Submit samples and product data of the acoustical panels, suspension system, and accessories. Submit suspension system in one-foot square package with all components of the system included. Design configuration of acoustical ceiling panels requires approval of the Engineer before the ceiling panels may be purchased for this work.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Ceiling Suspension System: ASTM C635, heavy-duty, electro-galvanized steel. Type of suspension system, grid size, and finish shall be as indicated. When not indicated, provide Direct Hung Suspension System. Color of finish shall be selected by the Engineer from the manufacturer's standard colors.

B. Acoustical Ceiling Panels: Fed. Spec. SS-S-118, Type as indicated, Class A. Light reflectance shall exceed 75 percent. Color, texture, and finish shall be as indicated. When not indicated, provide white, fissured texture acoustical panels. Acoustical ratings shall be as follows unless otherwise indicated: NRC not less than 0.60, STC not less than 35. Minimum thickness shall be 5/8 inch.

C. Access System: Access shall be such that any panel, anywhere, can be easily removed and reinstalled. System shall be such that panels do not raise or blow out of position from a differential in air pressure.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Verify that conditions are satisfactory for the installation of the acoustical ceiling system. If unsatisfactory conditions exist, notify the Engineer, and do not start the installation until such conditions have been corrected.

3.02 INSTALLATION REQUIREMENTS

A. Installation of ceiling panels shall not be started until windows and doors are installed and glazed and the air-conditioning (or heating and ventilating) system is in operation. All interior wet and dust-producing work shall be completed and dry.

B. At completion of the Work, all surfaces of ceiling panels and suspension system shall present true, level, and plane surfaces. Deviation from a level, plane surface shall not exceed 1/8 inch at any point in the ceiling. Surfaces of suspension system and ceiling panels shall be clean and unmarred over all areas, and shall present a finished appearance in all respects.

C. Layout Requirements:

1. Measure each ceiling area and establish layout of acoustical panels to balance border widths at opposite edges of each ceiling. Avoid using less-than-half-width panels at borders, and comply with layout shown on reflected ceiling plans.

2. Items attached to or installed in ceiling panels shall be centered in panels.

3.03 INSTALLATION

A. Installation of suspended ceilings shall conform to the applicable requirements of ASTM C636, except as otherwise indicated or required.

B. Suspension system and acoustical ceiling panels shall be installed in accordance with the manufacturer's installation instructions and recommendations.

C. Suspension system shall be securely hung from the structure above with No. 12 gage galvanized steel wire, spaced 4 feet on center along main T-bars. Include diagonal seismic bracing installed in accordance with UBC Std. 25-2 and approved details.

D. Where hanger wires are next to light fixtures and air diffusers, the spacing shall be two feet on center. There shall be hanging wires secured to the main T-bars at the perimeters of all light fixtures and air diffusers. Light fixtures and air diffusers themselves shall be provided with safety wires as required.

E. Hanger wires shall be securely fastened to the structure above as recommended by the manufacturer of the suspension system components and as required to meet applicable building code requirements.

F. Acoustical lay-in ceiling panels shall be installed in the completed grid system in accordance with the manufacturer's installation instructions and recommendations.

END OF SECTION 09 51 13

SECTION 09 63 19

STONE FLOORING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Granite.

B. Microporous sealer.

C. Mortar for setting bed.

D. Grout.

E. Reinforcement.

F. Cleavage membrane.

G. Sealant.

1.02 RELATED SECTIONS

A. Ceramic and quarry tile flooring and base are specified in Section 09 30 00, Tiling.

1.03 MEASUREMENT AND PAYMENT

A. General: Granite flooring and base will not be measured separately for payment but will be paid for as part of the Contract lump sum price for Architectural Work.

1.04 DEFINITIONS

A. The words and terms used in these Specifications conform with the definitions given in ASTM C119.

1.05 REFERENCES

A. American National Standards Institute (ANSI):

1. ANSI A108.1B	Ceramic Tile Installed on a Cured Portland Cement Mortar Setting Bed with Dry-Set or Latex-Portland Cement Mortar
2. ANSI A108.5	Ceramic Tile Installed with Dry-Set Portland Cement Mortar or Latex-Portland Cement Mortar
3. ANSI A108.10	Installation of Grout in Tilework
4. ANSI A118.1	Dry-Set Portland Cement Mortar

5. ANSI A118.6 Standard Ceramic Tile Grouts for Tile Installation

B. American Society for Testing and Materials (ASTM):

1. ASTM C97/C97M Standard Test Methods for Absorption and Bulk Specific Gravity of Dimension Stone
2. ASTM C99/C99M Standard Test Method for Modulus of Rupture of Dimension Stone
3. ASTM C119 Standard Terminology Relating to Dimension Stone
4. ASTM C144 Standard Specification for Aggregate for Masonry Mortar
5. ASTM C150/C150M Standard Specification for Portland Cement
6. ASTM C170/C170M Standard Test Method for Compressive Strength of Dimension Stone
7. ASTM C207 Standard Specification for Hydrated Lime for Masonry Purposes
8. ASTM C615/C615M Standard Specification for Granite Dimension Stone
9. ASTM C920 Standard Specification for Elastomeric Joint Sealants
10. ASTM D2178/D2178M Standard Specification for Asphalt Glass Felt Used in Roofing and Waterproofing

1.06 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit fully detailed Shop Drawings, showing granite flooring layouts, profiles, dimensions, bedding and joint details, and connections to adjoining work.

C. Product Data: Submit manufacturer’s specifications, catalog cuts, color range of granite, data sheets, installation instructions, and maintenance instructions. Submit certified test data for granite sample recently taken from representative areas of the supplying quarry, showing compliance with minimum physical characteristics specified.

D. Samples: Submit 12-inch-square units of granite flooring and finish specified and 12-inch finished lengths of base. Samples shall show full range of color and texture. Samples shall match the Engineer’s control samples. Also, provide sample of joint treatment, including one intersecting grouted joint, using actual granite flooring

mounted on plywood. Samples require approval of the Engineer before they may be used in the work.

1.07 QUALITY ASSURANCE

A. Granite shall be supplied from quarries having adequate capacity and facilities to meet the indicated requirements. Cutting and finishing shall be performed by skilled stone masons with substantial experience and the necessary equipment.

B. Any granite member or component showing flaws or imperfections upon receipt at the site shall be referred to the Engineer for a determination as to whether or not it will be rejected or may be patched or redressed for use in the work.

C. Chips at edges of granite flooring or other finished members will not be acceptable. Pieces with chipped edges shall be rejected but may be cut to smaller size if appropriate for use in the work.

D. The Engineer reserves the right to require tests of the specified physical characteristics be performed on samples taken from the area of the quarry from which the granite to be furnished is taken.

E. Granite shall match the Engineer's control samples in all respects. Control samples require the Engineer's approval before they may be used as a standard.

1.08 FIELD MOCK-UP

A. Requirements: Provide field mock-ups, as specified, for the Engineer's approval.

B. Typical Floor Panel: The Contractor shall install a typical floor panel, approximately 6 feet square in an appropriate location. Mock-up shall include joint treatment and other accessories as required for a finished installation. Keep panel damp until mortar has set; dry slowly to attain true appearance of finished work. Maintain accepted panel as the standard for completed work. Provide a typical floor panel for each different type of granite flooring and floor design indicated.

C. Acceptance: Approved typical floor panel will be used to establish acceptable minimum standards of appearance and work quality. Acceptance will be based on uniformity, color match, proper texture, and proper construction methods.

1.09 PRODUCT DELIVERY AND STORAGE

A. Deliver materials, other than bulk materials, in manufacturer's or supplier's unopened containers fully identified with name, brand, type, grade, class, size, color, and pattern. Store materials above ground and protect from weather and damage. Store in accordance with manufacturer's or supplier's instructions.

1.10 JOB CONDITIONS

A. Examine substrates and adjoining construction, and the conditions under which granite flooring work is to be installed, and do not proceed with the work until

conditions detrimental to the proper and timely completion of this work have been corrected.

B. Set and grout granite flooring when ambient temperature is above 50 degrees Fahrenheit. Do not set or grout granite flooring when ambient temperature is above 90 degrees Fahrenheit.

1.11 MAINTENANCE MATERIALS

A. Upon completion of the work, deliver to the Engineer an additional two percent of total of each granite flooring size, pattern, and color used on the job, for use in future repair and maintenance work. Furnish boxes of whole flooring units, sealed and properly identified. Include trim shapes.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Granite: Flooring and base shall be granite dimension stone conforming to applicable requirements of ASTM C615/C615M, sound, durable, free of cracks, seams, and starts; free of minerals which may cause staining under the conditions of use; and conforming to the following minimum physical requirements:

1. Absorption by Weight: 0.40 percent maximum when tested in accordance with ASTM C97/C97M.

2. Density: 160 pounds per cubic foot minimum when tested in accordance with ASTM C97/C97M.

3. Compressive Strength: 19,000 psi minimum when tested in accordance with ASTM C170/C170M.

4. Modulus of Rupture: 1,500 psi minimum when tested in accordance with ASTM C99/C99M.

B. Color, Texture, and Configuration: Color of granite shall be within the range of the Engineer's control samples. Dimensions, texture, and finish of granite shall be as indicated. Provide sanitary cove for base where indicated.

C. Trim Shapes: Include matching stops, returns, trimmers, nosings, and special shapes required to produce complete, neatly finished granite floor and base installations.

D. Microporous Sealer: Provide a microporous sealer, as recommended by the granite tile manufacturer, for sealing the backs of granite tile units to prevent warpage and curling of the granite units after installation.

E. Mortar for Setting Bed:

1. Cement: ASTM C150/C150M, Type I.

2. Lime: ASTM C207, Type S.

3. Sand: ASTM C144.

4. Water: Clean, potable, non-alkaline.

5. Mix: ANSI A108.1B. Include ANSI A108.5 bond or skim coat, using ANSI A118.1 dry-set portland cement mortar.

F. Grout: ANSI A118.6, colors as selected by the Engineer.

G. Reinforcement: Two-inch by two-inch mesh, 16 gage galvanized steel wire fabric.

H. Cleavage Membrane: ASTM D2178/D2178M, asphalt-impregnated glass felt, Type III - standard ply sheet.

I. Sealant: Mildew-resistant urethane or silicone sealant conforming to applicable requirements of ASTM C920. Provide Grade P for joints in horizontal surfaces and Grade NS for joints in vertical surfaces. Provide for M and G uses. Sealant may be Type S or Type M as appropriate. Color shall match grouted joints. Include proper backer rod where indicated or required.

2.02 FABRICATION

A. Dimensional Tolerances:

1. Thickness: Variation from the thickness indicated shall not exceed plus or minus 1/8 inch.

2. Face Dimension: Variation shall not exceed one fourth of the indicated joint width or one sixteenth inch, whichever is greater.

B. Flatness Tolerances:

1. Determine variation from true plane by means of a four-foot straightedge placed in any direction on the surface.

2. On polished, honed, or fine rubbed finishes, variation from a true plane shall not exceed one third of the indicated joint width or one sixteenth inch, whichever is greater. On thermal and sandblasted finishes, variation from a true plane shall not exceed one half of the specified joint width or three sixteenths inch, whichever is greater.

C. Rejection Criteria: The above-specified tolerances apply to occasional random variation in dimensions and flatness. Granite pieces which vary consistently in a manner which is detrimental to the quality of the finished work (for example, pieces which are consistently thinner than the indicated thickness or which are consistently cupped, bowed, or warped) shall be rejected even though each individual piece may be within the specified tolerances.

PART 3 – EXECUTION

3.01 EXAMINATION OF SUBSTRATE SURFACES

A. Examine subfloor and substrate surfaces to receive granite. Subfloor and substrate surfaces shall be firm, dry, clean, and free from defects or irregularities that may impair bond or jeopardize the quality of the work, and no paving or flooring work shall be performed over affected areas until suitable corrections have been made.

3.02 INSTALLATION

A. Install granite flooring and base in full mortar setting bed as indicated and in accordance with applicable requirements of ANSI A108.1B. Minimum thickness of mortar setting bed shall be three fourth inch.

B. Granite shall be cleaned and sponged with clean water just before setting. Each unit of granite shall be set level, true to line, with uniform joint widths, as indicated.

C. All joints shall be raked out three eight inch in depth, cleaned, dampened, and pointed full and flush with joint mortar or grout. Conform with applicable requirements of ANSI A108.10. Joints shall be densely tooled flat at one sixteenth inch below face of granite. Faces of granite shall be kept free of mortar and grout.

D. Provide expansion joints in granite flooring and base where indicated. Provide sealant and backer rod as required. Joints shall coincide with building expansion joints where they occur, and shall penetrate the setting bed completely.

E. Install cleavage membrane over concrete or masonry surfaces where indicated or required.

F. Install metal reinforcement in mortar setting bed for flooring where indicated or required.

3.03 INSTALLATION TOLERANCES

A. Joint Arris Lines: One sixteenth inch maximum variation for honed and polished finishes; one eighth inch maximum variation for thermal finish.

B. Joint Width: Plus or minus one sixteenth inch.

3.04 PROTECTION

A. After installation, protect granite from damage until completion and acceptance of the work by the District. Do not use lumber or other material that may stain the granite. Provide non-staining building paper and clean plywood in areas to be walked on by workers.

3.05 CLEANING

A. Upon completion of the work, clean granite, point open joints, and replace defective work. Do not use acids, abrasive cleaners, or wire brushes.

END OF SECTION 09 63 19

SECTION 09 65 16

RESILIENT SHEET FLOORING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Sheet vinyl flooring.

B. Edging strips.

C. Base.

D. Underlayment and floor patch.

E. Adhesives and primers.

1.02 MEASUREMENT AND PAYMENT

A. General: Resilient sheet flooring and base will not be measured separately for payment but will be paid for as part of the Contract lump sum price for Architectural Work.

1.03 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM E84 Standard Test Method for Surface Burning Characteristics of Building Materials
2. ASTM E648 Standard Test Method for Critical Radiant Flux of Floor-Covering Systems Using a Radiant Heat Energy Source
3. ASTM E662 Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials
4. ASTM F1861 Standard Specification for Resilient Wall Base
5. ASTM F1303 Standard Specification for Sheet Vinyl Floor Covering with Backing

B. Resilient Floor Covering Institute (RFCI):

1. RFCI Installation

C. National Sanitation Foundation (NSF)/American National Standards Institute (ANSI)

1. NSF/ANSI 332 Sustainability Assessment for Resilient Floor Coverings

D. California Code of Regulations (CCR)

1. Title 24, Part 11, California Green Building Standards Code (CalGreen)

E. National Fire Protection Association

1. NFPA 101 Life Safety Code

1.04 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures. Adhere to CalGreen Section 5.504.4.6.1 documentation requirements.

B. Samples: Submit samples of sheet vinyl flooring, edge trim, resilient base, and accessories. Sheet vinyl flooring and base require approval of the Engineer before they may be purchased for this Work.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Sheet Vinyl Flooring: ASTM F1303, Type II, Grade 1. Sheet vinyl flooring shall meet the following requirements:

1. Flame Spread: 25 maximum, according to NFPA 101, Section 10.2.3.4.1, when tested in accordance with ASTM E84.

2. Smoke Developed: 450 maximum when tested in accordance with ASTM E662.

3. Critical Radiant Flux: 0.45 minimum when tested in accordance ASTM E648.

4. Gage: 0.080 inch minimum.

5. Color and Pattern: As indicated, or as selected by the Engineer from manufacturer’s standards.

6. Low Emitting Material: Adhere to CalGreen Section 5.504.4.6.

7. Sustainability: NSF/ANSI 332

B. Edging Strips: Molded vinyl, one-and-one-half inch by one-eighth inch thick, with exposed edge one-fourth rounded, in color as selected by the Engineer from manufacturer’s standards.

C. Base: ASTM F1861, topset cove, solid vinyl or rubber.

1. Size: Four-inches high, unless otherwise indicated.

2. Color: As indicated, or as selected by the Engineer from manufacturer's standards.

D. Underlayment and Floor Patch: Floor patch and leveling compound or underlayment shall be products manufactured for the purpose as recommended by the manufacturer of the resilient flooring furnished.

E. Adhesives and Primers: Products specified or recommended by the manufacturer of the particular resilient flooring and base furnished.

PART 3 – EXECUTION

3.01 INSPECTION AND PREPARATION OF SURFACES

A. Inspection of Substrate Surfaces: Before starting the installation of resilient flooring and base, examine all surfaces on which the finish flooring and base are to be applied. Examination includes bond, moisture, and alkali testing of concrete subfloors. Any defective surfaces or conditions preventing proper execution of the work shall be corrected as required.

B. Cleaning and Preparation of Substrate Surfaces: Subsurfaces and backing surfaces shall be dry, clean of dust, paint spots, grease, and bond breaking or curing compounds. Subsurfaces shall also be free from roughness and sharp edges to prevent protrusions and bulges after resilient material is laid or applied. Fill all joints, cracks, and depressions in concrete slabs with specified floor patch and underlayment material. Grind down ridges and high spots flush and smooth with surrounding surfaces.

C. Beginning Work: Installation shall not begin until the work of other trades in the area, including painting, has been completed.

D. Responsibility: Nothing specified herein shall be construed as relieving the Contractor of any responsibility for the quality of the finished installation. Surfaces on which resilient flooring and base are to be applied shall be level and in proper condition in every respect for an acceptable installation and long life without defects.

3.02 INSTALLATION

A. Installation Standards: Comply with RFCI Installation and ASTM F1861, as appropriate.

B. Installation Requirements: Keep materials at a temperature of 70 degrees Fahrenheit or higher for at least 48 hours before using, and maintain 70 degrees Fahrenheit or higher room temperatures at least three days before, during, and after application of materials. Apply materials in accordance with the sheet vinyl manufacturer's installation instructions. Materials shall be installed only by skilled and experienced applicators authorized and approved by the manufacturer.

C. Sheet Vinyl Flooring:

1. Installation System: Sheet vinyl flooring shall be installed in accordance with the sheet vinyl flooring manufacturer's instructions.

2. Application of Adhesive: Apply specified adhesive with a notched steel trowel to ensure an even bed of adhesive. Cross-trowel to achieve an even thickness.

3. Sheet Vinyl Layout: Layout vinyl sheet to ensure minimum number of seams. Only "perfects" shall be used so that cross seams shall be kept to absolute minimum. Lay sheets firmly against adjacent sheets to minimize joints. Neatly scribe around pipes, fixtures, and equipment to form tight, hairline joints free of gaps.

4. Sheet vinyl at Permanent Cabinets: Sheet vinyl flooring is not required under fixed cabinets having covered fronts and integral bottoms and which are permanently anchored to the structure.

5. Edging Strips: Install edging strips wherever sheet vinyl terminates at an opening or where there is an unprotected edge. Top of strips shall be flush with top of sheet vinyl flooring.

D. Complete resilient flooring installation before applying base. Install base on all walls as indicated and on fronts, toe spaces, and finished backs and ends of cabinets with adhesive recommended by manufacturer of base. Apply adhesive to both wall and base and press firmly into place. Maintain top edge at true horizontal line. Toe of coved base shall contact floor for entire length. Closely butt end joints, top edge, and faces flush. Remove excess adhesive.

3.03 CLEANING, SEALING, AND PROTECTION

A. Traffic: Until floors are well seated at least 72 hours at a maintained temperature of not less than 70 degrees Fahrenheit, traffic shall be kept to an absolute minimum, and fixtures, equipment, trucks, and similar equipment or vehicles shall not be permitted to travel over floors.

B. Cleaning and Sealing: Just before turning finished spaces over to the Engineer, and not before, clean resilient flooring and base thoroughly in accordance with the flooring manufacturer's recommendations. After cleaning, apply one coat of approved non-skid finish to floors and polish with a mechanical buffer.

C. Protection: Install clean plywood or board walks over clean, non-staining building paper where any traffic from other trades must pass over completed resilient floors. Maintain protection until acceptance by the District and Contract substantial completion.

END OF SECTION 09 65 16

SECTION 09 65 19

RESILIENT TILE FLOORING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Resilient tile.

B. Edging strips.

C. Base.

D. Underlayment and floor patch.

E. Adhesives and primers.

1.02 MEASUREMENT AND PAYMENT

A. General: Resilient tile flooring and base will not be measured separately for payment but will be paid for as part of the Contract lump sum price for Architectural Work.

1.03 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM E84 Standard Test Method for Surface Burning Characteristics of Building Materials
2. ASTM E648 Standard Test Method for Critical Radiant Flux of Floor-Covering Systems Using a Radiant Heat Energy Source
3. ASTM E662 Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials
4. ASTM F1066 Standard Specification for Vinyl Composition Floor Tile
5. ASTM F1700 Standard Specification for Solid Vinyl Floor Tile
6. ASTM F1861 Standard Specification for Resilient Wall Base

B. Resilient Floor Covering Institute (RFCI):

1. RFCI Installation

C. National Sanitation Foundation(NSF)/ American National Standards Institute (ANSI)

1. NSF/ANSI 332 Sustainability Assessment for Resilient Floor Coverings

D. National Fire Protection Association

1. NFPA 101 Life Safety Code

1.04 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Samples: Submit samples of resilient tile, resilient base, edge trim, and accessories. Resilient tile and base require approval of the Engineer before they may be purchased for this work.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Tile: ASTM F1066 and F1700. Resilient tile shall meet the following requirements:

1. Flame Spread: 25 maximum, according to NFPA 101, Section 10.2.3.4.1, when tested in accordance with ASTM E84.

2. Smoke Developed: 450 maximum when tested in accordance with ASTM E662.

3. Critical Radiant Flux: 0.45 minimum when tested in accordance with ASTM E648.

4. Gage: 1/8 inch.

5. Size, Color, and Pattern: As indicated, or as selected by the Engineer from manufacturer's standard colors and patterns. Color and pattern shall extend through the body of the tile.

6. Sustainability: NSF/ANSI 332.

B. Edging Strips: Molded vinyl 1-1/2 inch by 1/8-inch thick, with exposed edge 1/4-rounded, in color as selected by the Engineer from manufacturer's standards.

C. Base: ASTM F1861, topset cove, solid vinyl or rubber.

1. Size: Four inches high, unless otherwise indicated.

2. Color: As indicated, or as selected by the Engineer from manufacturer's standard colors.

D. Underlayment and Floor Patch: Floor patch and leveling compound or underlayment shall be products manufactured for the purpose as recommended by the manufacturer of the resilient flooring furnished.

E. Adhesives and Primers: Products specified or recommended by the manufacturers of the particular resilient flooring and base furnished.

PART 3 – EXECUTION

3.01 INSPECTION AND PREPARATION OF SURFACES

A. Inspection of Substrate Surfaces: Before starting the installation of resilient flooring and base, examine all surfaces on which the finish flooring and base are to be applied. Examination includes bond, moisture, and alkali testing of concrete subfloors. Any defective surfaces or conditions preventing proper execution of the work shall be corrected as required.

B. Cleaning and Preparation of Substrate Surfaces: Subsurfaces and backing surfaces shall be dry, clean of dust, paint spots, grease, and bond breaking or curing compounds. Subsurfaces shall also be free from roughness and sharp edges to prevent protrusions and bulges after resilient material is laid or applied. Fill all joints, cracks, and depressions in concrete slabs with specified floor patch and underlayment material.

C. Beginning Work: Installation shall not begin until the work of other trades in the area, including painting, has been completed.

D. Responsibility: Nothing specified herein shall be construed as relieving the Contractor of any responsibility for the quality of the finished installation. Surfaces on which resilient flooring and base are to be applied shall be level and in proper condition in every respect for an acceptable installation and long life without defects.

3.02 INSTALLATION

A. Installation Standards: Comply with RFCI Installation and ASTM F1861, as appropriate.

B. Installation Requirements: Keep materials at a temperature of 70 degrees Fahrenheit or higher for at least 48 hours before using, and maintain 70 degrees Fahrenheit or higher room temperatures at least three Days before, during, and after application of materials. Apply materials in accordance with the flooring manufacturer's installation instructions. Materials shall be installed only by skilled and experienced applicators authorized and approved by the flooring manufacturer.

C. Resilient Tile:

1. Tile Layout: Lay out center lines in both directions of room parallel to walls. Adjust to make cut tile borders of equal width on opposite sides. Avoid using less-than-half-width tiles. Lay tile with joints aligned and without contrasting borders. Lay tile with grain running in the same direction.

2. Application of Adhesive: After joints, cracks, and depressions in concrete slabs have been filled with floor patch and leveling compound, and floors have been

primed (if recommended by flooring manufacturer), apply the specified adhesive with a notched steel trowel to ensure an even bed of adhesive for the tile. Cross-trowel to achieve an even thickness.

3. Laying of Tile: Lay tile when adhesive has set tacky, starting at the center of the room and working toward walls. Embed each tile in adhesive with closely fitted, straight, hairline joints. Do not cut tile except at walls or obstructions. Neatly scribe around pipes, fixtures, and equipment to form tight joints free of gaps. Finished floors shall be smooth and free from buckles, cracks, breaks, waves, and projecting edges and shall fit neatly at pipes and other installations and obstructions. Remove excess adhesive.

4. Tile at Permanent Cabinets: Tile is not required under fixed cabinets having covered fronts and integral bottoms and which are permanently anchored to the structure.

5. Edging Strips: Install edging strips wherever tile terminates at an opening or where there is an unprotected edge. Top of strips shall be flush with top of tile.

D. Base: Complete resilient flooring installation before applying base. Install base on all walls as indicated and on fronts, toe spaces, and finished backs and ends of cabinets with adhesive recommended by manufacturer of base. Apply adhesive to both wall and base and press firmly into place. Maintain top edge at true horizontal line. Toe of coved base shall contact floor for entire length. Closely butt end joints, top edge, and faces flush. Remove excess adhesive.

3.03 CLEANING, SEALING, AND PROTECTION

A. Traffic: Until floors are well seated, at least 72 hours, at a maintained temperature of not less than 70 degrees Fahrenheit, traffic shall be kept to a minimum, and fixtures, equipment, trucks, and similar equipment or vehicles shall not be permitted to travel over floors.

B. Cleaning and Sealing: Just before turning station structure or building over to the District, and not before, clean resilient flooring and base thoroughly in accordance with the flooring manufacturer's recommendations. After cleaning, apply one coat of approved non-skid finish to floors and polish with a mechanical buffer.

C. Protection: Install clean plywood or board walks over clean, non-staining building paper where any traffic from other trades must pass over completed resilient floors. Maintain protection until acceptance by the District and Contract substantial completion.

END OF SECTION 09 65 19

SECTION 09 67 70

ELEVATOR SPRAY-ON FLOORING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Spray floor system requirements.

B. Spray application.

C. Performance characteristics.

D. Installation procedures.

1.02 RELATED SECTIONS

A. Section 14 21 00, Electric Traction Elevators

B. Section 14 24 00, Hydraulic Elevators

1.03 MEASUREMENT AND PAYMENT

A. Separate measurement and payment will not be made for work required under this Contract Specifications Section. All costs in connection therewith will be considered incidental to the item of work to which they pertain.

1.04 REFERENCES

A. American Society for Testing Materials (ASTM):

1. ASTM D4541 Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers

2. ASTM D412 Standard Test Method for Vulcanized Rubber and Thermoplastic Elastomer

3. ASTM D2240 Standard Test Method for Shore D Hardness

1.05 SUBMITTALS

A. Contractor shall submit to the District a list of the materials to be used in the spray flooring system material application. The submittal shall include the corresponding Material Safety Data Sheets (MSDS) for the various compounds to be used, including solvents, primer coat, membrane coat, top coat, accent speckles, and non-skid sealer. Contractor shall submit color swatches for approval. Color shall match previously sprayed existing elevators, which is slate gray.

1.06 QUALITY ASSURANCE

A. The Contractor shall keep adequate and current production records including information relating to the control consistency and quality of the spray coat flooring material.

B. District may audit the work in progress and records pertaining to the spray coat flooring.

C. The intended minimum service life for each new installed spray coated floor is expected to be 10 years. Contractor shall warranty the new floor from defects in material quality and craftsmanship for 3 years after the date of installation.

D. For every elevator, the Contractor shall keep records of the work done; records shall document elevator number, production number, date of production, temperature of the spray, pressure, quantity of spray used, and any information pertinent to the Work performed.

E. The Contractor shall facilitate a thorough inspection by the Engineer to record punch-list items to be completed prior to Acceptance.

F. Installer shall be experienced in the application of polyurea spray and have a minimum of 50,000 gallons of spray application experience in high profile public access areas and shall be certified by the manufacturer.

1.07 SITE CONDITIONS

A. The substrate to receive application work shall be clean and dry of any moisture and contaminates that could affect the performance of the flooring material.

B. Aboveground locations: application work may be applied during regular business hours.

C. Underground locations: application work shall be applied during non-revenue hours with the nearest tunnel ventilation fan on, in exhaust mode.

PART 2 – PRODUCTS

2.01 PRODUCT REQUIREMENTS

A. Spray-on Flooring: Precidium 550D-FR, designated matching product (DMP) high performance, polyuria elastomer, two-part compound mixed in a 1 to 1 ratio resin under conditions specified by the manufacturer, Quantum Technical Services Ltd. (Quantum) and with the specialized equipment and controls, specified by the manufacturer. Product shall be applied as a spray to a properly prepared surface. Product shall have the following performance characteristics:

1. Flame resistance
2. Zero Volatile Organic Compound (VOC)
3. 24 hour curing time

B. Primer: as recommended by manufacturer.

C. Sealer: as recommended by manufacturer.

D. Final finish on floor shall have no less than a 0.6 coefficient of friction for both wet and dry conditions.

PART 3 – EXECUTION

3.01 INSTALLATION

A. The installer shall be certified by the manufacturer and use the best practices, methods and techniques and the appropriate equipment in the performance of the Work.

B. The installer shall be responsible for the safety of its working crew, and shall provide its personnel safety protection equipment as required by the federal, state, and local regulatory agencies.

C. The spray coat flooring material application shall be performed in a safe manner and shall be in compliance with the environmental, federal, state and local agency safety regulations.

D. The sprayed-on material shall be built up to achieve flush transition with the elevator cab sill.

E. Apply primer coat 3 mils thick over flooring substrate in accordance with the manufacturer's details.

F. Apply spray-on flooring to a total thickness of 80 to 100 mils. Hot plural spray applied only. Maintain an even distance from surface providing a uniform application with an overlap from one pass to the next.

G. Top coat shall be applied to a thickness of 6 to 8 mils.

H. Multicolor accent details shall be applied to a thickness of 6 to 8 mils.

I. Apply sealer 100 grit no longer than 6 hours after installation at manufacturer's recommended coverage rates of 5 to 9 mils. If longer than 6 hours, refer to manufacturer's recoat instructions.

J. Contractor shall sample air during and throughout the flooring application by an independent certified person and only terminated upon the Engineer's request.

END OF SECTION 09 67 70

SECTION 09 83 14

ACOUSTIC COATING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Spray-applied acoustical finish material.

B. Bonding agent.

1.02 RELATED REQUIREMENTS

A. Precast concrete panels for acoustical barriers are specified in Section 03 40 00, Precast Concrete.

1.03 MEASUREMENT AND PAYMENT

A. General: Acoustical barriers and acoustical treatments will not be measured separately for payment but will be paid for as part of the Contract lump sum price for Architectural Work.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM C423 Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method
2. ASTM E84 Standard Test Method for Surface Burning Characteristics of Building Materials
3. ASTM E605/E605M Standard Test Methods for Thickness and Density of Sprayed Fire-Resistive Material (SFRM) Applied to Structural Members
4. ASTM E736/E736M Standard Test Method for Cohesion/Adhesion of Sprayed Fire-Resistive Materials Applied to Structural Members
5. ASTM E759/E759M Standard Test Method for Effect of Deflection on Sprayed Fire-Resistive Material Applied to Structural Members
6. ASTM E761/E761M Standard Test Method for Compressive Strength of Sprayed Fire-Resistive Material Applied to Structural Members

7. ASTM E859/E859M Standard Test Method for Air Erosion of Sprayed Fire-Resistive Materials (SFRMs) Applied to Structural Members

1.05 COORDINATION

A. Coordinate the work of this Section with the work of providing facilities for sprinkler system and plumbing system piping, electrical conduits, and other interfacing work as required.

1.06 SUBMITTALS

A. General: Refer to Sections 01 33 00, Submittal Procedures, and 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Product Data: Submit manufacturer's product data, including catalog cuts, specifications, and installation instructions.

C. Samples: Submit sample, eight inches by 10 inches in size, of the spray-applied acoustical finish, applied full thickness on plywood backing.

D. Test Reports: Submit certified test reports on bond strength, compressive strength, density, and sound absorption (Noise Reduction Coefficient).

1.07 QUALITY ASSURANCE

A. Refer to Section 01 43 00, Quality Assurance, for applicable quality assurance requirements.

B. Spray-applied acoustical finish shall be applied by a specialist applicator/subcontractor skilled and experienced in the type of work involved. The Contractor shall ensure that the applicator/subcontractor is licensed and approved by the acoustical material manufacturer.

C. The Contractor shall ensure that the acoustical material manufacturer inspects and approves the concrete substrate preparation and the acoustical material application, and provides field services at no additional cost to the District.

D. The Contractor shall make necessary arrangements with the acoustical material manufacturer to provide on-site consultation and inspection services to assure the correct substrate preparation and application of the acoustical finish material.

E. The Contractor shall ensure that the acoustical material manufacturer's representative is present at the time any phase of the work is started and periodically as the work progresses. Spray-applied acoustical finish shall be applied only over properly prepared substrate surfaces previously approved by the material manufacturer's representative.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Spray-Applied Acoustical Finish Material: Heavy-duty, exterior grade, cementitious acoustical finish material, meeting the following physical performance standards:

1. Dry Density: Minimum average dry density of 40 pounds per cubic foot when tested in accordance with ASTM E605/E605M.

2. Compressive Strength: Minimum compressive strength of 850 psi when tested in accordance with ASTM E761/E761M.

3. Bond Strength: Minimum average bond strength of 7,200 psf when tested in accordance with ASTM E736/E736M.

4. Surface Burning Characteristics: When tested in accordance with ASTM E84:

Flame Spread:	0
Smoke Development:	0

5. Sound Absorption: 0.60 Noise Reduction Coefficient (NRC) at one-inch thickness with coefficient not less than 0.19 at 250 Hz when tested in accordance with ASTM C423.

6. Deflection: Material shall not crack or delaminate from the surface to which it is applied when tested in accordance with ASTM E759/E759M.

7. Air Erosion: Maximum total weight loss of 0.005 gram per square foot when tested in accordance with ASTM E859/E859M.

B. Mixing Water: Clean and potable.

C. Bonding Agent: As recommended by the manufacturer for the type of substrate.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Examine concrete substrate for surfaces containing curing compounds, form coatings and oils, grease, paint, and other defects that may impair bond with the acoustical finish material.

B. Anchors, clips, hangers, support sleeves, and other attachments required to penetrate the acoustical finish for the hanging and support of pipes, ducts, and conduits shall be in place before the acoustical finish application begins. However, actual installation of piping, ducts, and conduits shall not take place until after the

acoustical finish work is completed and dry as recommended by the acoustical material manufacturer.

3.02 PREPARATION

A. Remove form coatings and oils, dust, dirt, and any other incompatible material that may impair bond by scraping, brushing, scrubbing, or water blast as necessary.

B. Prepare substrate surfaces by filling voids, cracks, and offsets as recommended by the acoustical material manufacturer. Remove projections that may telegraph such imperfections.

C. Prepare and prime substrate surfaces with bonding agent recommended by the acoustical material manufacturer.

D. Provide masking to contain overspray and drop cloths to protect floors and other surfaces below from droppings and other debris.

3.03 APPLICATION

A. Application of the spray-applied acoustical ceiling finish shall be in accordance with the manufacturer's application instructions and recommendations.

B. Minimum dry thickness of the acoustical finish shall be one inch.

3.04 FIELD QUALITY CONTROL

A. The Engineer will sample and verify the thickness and density of the acoustical ceiling finish in accordance with ASTM E605/E605M.

END OF SECTION 09 83 14

SECTION 09 91 00

PAINTING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Paint materials.

B. Accessory materials.

1.02 DESCRIPTION

A. The work includes the painting and finishing of exterior and interior exposed surfaces throughout the Contract, except as otherwise indicated. Surface preparation, priming, and coats of paint specified are in addition to shop priming and surface treatment specified under other Sections of the Specifications.

B. The work includes the field painting of bare and covered pipes (including color coding in accordance with ASME A13.1), and of hangers, exposed steel and iron work, and primed metal surfaces of equipment except as otherwise indicated.

C. The work includes restoration of existing painted surfaces as indicated. Extent of restoration work involving existing painted surfaces is indicated on the Contract Drawings.

D. Paint exposed surfaces whether or not colors are designated in any schedule, except where the natural finish of the material is specifically indicated as a surface not to be painted. Where surfaces are not specifically identified, paint such surfaces the same as adjacent similar surfaces.

E. The paint systems specified indicate the basic painting systems. Deviations within the system, such as the use of two finish coats in lieu of undercoat and finish, will be permitted only where such procedure is recommended by the paint manufacturer and approved by the Engineer.

1.03 DEFINITIONS

A. The term “paint” as used herein means all coating systems materials, and includes primers, emulsions, enamels, stain, sealers and fillers, and other applied materials whether used as prime, intermediate, or finish coats.

1.04 WORK NOT INCLUDED IN THIS SECTION

A. Shop or Factory Primed Surfaces: Shop priming of ferrous and galvanized metal items is included under the various Sections for structural steel, metal decking, miscellaneous metal items, hollow metal work, and similar items, and shop-fabricated or factory-built mechanical and electrical equipment and accessories.

B. Pre-Finished Items: Field finish does not include painting when factory-finishing is specified for items such as acoustical materials, finished mechanical and electrical equipment, including light fixtures and distribution cabinets. Field touch-up is required, however, in all cases where the factory finish is damaged.

C. Concealed Surfaces: Painting is not required on wall or ceiling surfaces in concealed areas and generally inaccessible areas, such as foundation spaces, furred areas, utility tunnels, pipe spaces, duct shafts, and elevator hoistways without vision panels. Paint piping, equipment, and other such items within these areas as indicated.

D. Nonferrous Metal Surfaces: Anodized aluminum, stainless steel, copper, and similar nonferrous metal materials will not require finish painting unless otherwise indicated or specified.

E. Operating Parts and Labels:

1. Moving parts of operating units, mechanical and electrical parts, such as valve and damper operators, linkages, sensing devices, motor and fan shafts, and expansion joints, will not require finish painting unless otherwise indicated.

2. Do not paint over code-required labels, such as UL, FM, and WH, or equipment identification, performance rating, name, or nomenclature plates.

3. Do not paint automatic fire sprinkler heads.

F. Graffiti-Resistant Coatings: Anti-graffiti coatings are specified in Section 09 96 33, Graffiti-Resistant Coatings.

G. Miscellaneous Surfaces: Rubber and elastomeric sealants, cementitious fireproofing, and machined surfaces of metal hardware and related fittings will not require finish painting.

1.05 MEASUREMENT AND PAYMENT

A. General

1. Paint and painting will not be measured separately for payment but will be paid for as part of the Contract lump sum price for Architectural Work.

2. When painting is required for surfaces which are not a part of the Architectural Work, or when there is no Architectural Work, paint and painting will be measured separately for payment by the lump sum, as indicated in the Bid Schedule of the Bid Form, and will be paid for as part of the Contract lump-sum price for painting.

1.06 REFERENCES

A. American Society of Mechanical Engineers (ASME):

1. ASME A13.1 Scheme for the Identification of Piping Systems

B. Painting and Decorating Contractors of America (PDCA):

1. “Painting and Decorating Craftsman’s Manual and Textbook”

C. The Society for Protective Coatings (SSPC):

1. SSPC Painting Manual, Volume 2, “Systems and Specifications”

2. SSPC-SP 1 Solvent Cleaning

3. SSPC-SP 3 Power Tool Cleaning

4. SSPC-SP 6/NACE No.3 Commercial Blast Cleaning

5. SSPC-SP 10/NACE No. 2 Near-White Blast Cleaning

D. American Society of Testing and Materials (ASTM):

1. ASTM D360 Standard Specification for Shellac Varnishes

1.07 QUALITY ASSURANCE

A. Regulatory Requirements: Paint products and solvents shall comply with the latest regulations of the Bay Area Air Quality Management District regarding regulations governing permissible content of volatile organic compounds (VOC). Refer to Section 01 81 31, Sustainability Requirements.

B. Quality Standards:

1. Preparation and painting work shall conform with the recommended practices and quality standards of the “Painting and Decorating Craftsman’s Manual and Textbook,” latest edition, published by the Painting and Decorating Contractors of America.

2. Preparation and painting of steel surfaces shall conform with the quality standards of the SSPC Painting Manual, Volume 2.

3. Paints, enamels, stains, lacquers, and varnishes shall be applied in accordance with the manufacturers’ latest specifications, instructions, and recommendations.

C. Paint Coordination:

1. Coordinate and interface the work of this Section with the various Sections specifying factory-applied finishes.

2. Coordinate the work of this Section with the work specified under Mechanical and Electrical, for color-coding and painting of mechanical and electrical equipment, piping, conduit, ducts, and panels.

3. Provide finish coats that are fully compatible with the prime paints used. Field-applied primers shall be supplied by the same manufacturer as the intermediate (if any) and finish coats used. Review other Sections of these Specifications in which prime paints are specified to ensure compatibility of the coating system for each of the various substrates. Provide barrier coats over incompatible primers or remove and reprime as required.

D. Paint Manufacturer's Review: Before purchasing paint materials, review the proposed paint systems, materials, and substrates with qualified representatives of the proposed paint products manufacturer. Obtain manufacturer's concurrence of the proposed paint systems, or any recommended changes thereto, before providing product data, samples, and mock-ups specified in Articles 1.06 and 1.07 herein.

1.08 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Manufacturers' Review: Submit record of paint manufacturer's review as specified above in Article 1.05.D.

C. Product Data:

1. Submit a complete list of all materials proposed for use, together with manufacturers' product specifications for such products.

2. No claim by the Contractor concerning the unsuitability of any material specified, or the Contractor's inability to produce first class work with such materials, will be considered unless such claim is made in writing to the Engineer before the work is started.

3. Provide product documentation of VOC content in g/L.

D. Colors and Samples:

1. Colors: The Engineer will prepare a Color Schedule with samples for guidance of the painter, and reserves the right to select, allocate, and vary colors on different surfaces throughout the station or building, subject to the limitation that not more than 20 percent of bright or deep colors will be selected.

2. Samples:

a. Before beginning work, prepare for approval a sample of each color, texture, and finish required. Such samples, when approved, shall constitute standards for color, texture, and finish of completed work.

b. Make samples eight by 10 inches in size and upon materials corresponding with those to be finished in the station or building.

c. When samples are rejected, a maximum of two additional modified samples may be required, in each instance, to obtain approval.

d. Approved samples shall be marked for identification and shall be distributed to the Engineer and field offices as required.

e. Mock-up for approval of final colors shall match the approved colors and samples.

1.09 MOCK-UP FOR APPROVAL OF FINAL COLORS

A. Final coat of paint and finish for both exterior and interior shall not be applied until the colors and textures have been approved by the Engineer. To accomplish this, the Contractor shall paint a sample panel of approximately 24 square feet of the colors and textures selected on every surface of the station or building to be painted. The Engineer will approve the sample panels or direct changes as desired.

B. The Contractor shall be on the job and be prepared to change sample panels to colors and textures desired. The Contractor shall notify the Engineer at least three Days in advance of when sample panels will be ready to receive approval.

C. Notice shall not be given, however, until permanent fluorescent and incandescent lights are installed and in operation in the rooms or areas where the sample panels have been painted. Temporary lights at the same level and of the same type, intensity, and color as the permanent lights will be permitted for viewing of sample panels.

1.10 DELIVERY AND STORAGE

A. Refer to Section 01 60 00, Product Requirements, for general requirements.

B. Deliver paint materials to the site in original, unopened packages and containers with labels intact and seals unbroken.

C. Store materials, tools, and equipment in a locked, properly ventilated, designated storage space on the site, assigned for this purpose. Receiving, opening, and mixing of paint materials shall be performed in this storage space. Keep storage space neat, clean, and accessible at all times. Protect areas from paint spillage.

D. Place paint-soaked or solvent-soaked rags, waste, and other materials that might constitute a fire hazard in closable metal containers and remove from the premises at the close of each day’s work. Take all necessary precautions to avoid fire danger.

1.11 WEATHER AND TEMPERATURE

A. Surfaces shall be painted only when they are free from moisture. No painting on exterior surfaces shall be performed less than 72 hours of actual drying weather after a rain, or during periods of dew or fog. Receiving surfaces shall be properly dried out before proceeding with the work.

B. No painting shall be performed when temperature is below 40 degrees Fahrenheit and above 90 degrees Fahrenheit or when the relative humidity is above 90 percent, unless recommended otherwise in writing by the paint manufacturer.

1.12 SCAFFOLDING AND PROTECTION

A. Furnish, maintain, and remove all scaffolding, ladders, and planks required for this work, and all drop cloths for the protection of concrete walks, floors, adjacent surfaces, prefinished materials, building fixtures, and similar surfaces.

B. Painted and finished surfaces subject to damage or defacement due to other work in the station or building shall be properly protected and covered. The Contractor shall be responsible for damage to painted work and to that of other work caused by painting operations under this Section until final acceptance by the District.

PART 2 – PRODUCTS

2.01 PAINT QUALITY STANDARDS

A. Paint and painter's finish shall be the highest quality products of nationally recognized manufacturers specializing in the manufacture of paint products. Minimum percent solids (MPS) required for the paint products herein specified shall be as indicated in the following example: MPS: 35.

B. Provide primer and undercoater paints produced by the same manufacturer as the intermediate and finish coats. Use thinners approved by the paint manufacturer which meet previously referenced regulatory requirements, and provide only to recommended limits.

C. Provide primers and undercoaters which are suitable for each surface to be painted and which are compatible with specified intermediate and finish paint coats.

D. Materials necessary to complete the painting work are herein generically specified. Except as otherwise specified, materials for any one paint system shall be by the same manufacturer.

E. Minimum dry film thicknesses (MDFT), in mils, and the number of coats required to obtain such thicknesses shall be in accordance with the paint manufacturer's application instructions and recommendations.

F. Refer to VOC limits under Section 01 81 13, Sustainability Requirements. Adhere to CalGreen Section 5.504.4.3 for pollutant of paints and coatings.

2.02 PAINT MATERIALS

A. Type and Manufacture: The following products constitute the standards for the primers, intermediate, and finish coats of the paint systems herein specified in articles 3.04 and 3.05.

1. Ferrous Metal Primer: Refer to Section 05 12 00, Structural Steel Framing, and Section 05 50 00, Metal Fabrications, for requirements.

2. Galvanized Metal Primer: Refer to Section 05 50 00, Metal Fabrications, for requirements.

3. Masonry Surface Conditioner: Acrylic latex masonry filler. MPS: 35.

4. Exterior Masonry Paint: Exterior 100 percent acrylic latex masonry paint. MPS: 35.

5. Exterior Wood Primer: Exterior wood primer as recommended by the manufacturer for the location and conditions. MPS: 40.

6. Exterior House and Trim Paint: Exterior enamelized house and trim paint for wood and metal. MPS: 40.

7. P.V.A. Primer-Sealer: Polyvinyl-acetate primer-sealer for interior gypsum board (drywall). MPS: 30.

8. Alkyd Primer-Sealer: Alkyd or acrylic latex primer sealer for interior plaster, concrete, masonry, and gypsum board (drywall). MPS: 30.

9. Enamel Undercoat: Alkyd or acrylic latex enamel undercoater. MPS: 35.

10. Semi-Gloss Enamel: Alkyd or acrylic latex enamel, semi-gloss sheen, washable. MPS: 35.

11. Eggshell Enamel: Alkyd or acrylic latex enamel, eggshell sheen, washable. MPS: 35.

12. Heavy-Duty Gloss Enamel: Heavy-duty, industrial grade, polyurethane, gloss sheen. MPS: 45.

13. Interior Flat Latex Paint: Interior flat latex paint for drywall; not washable. MPS: 30.

14. Floor Enamel: Acrylic latex floor enamel for concrete floors, semi-gloss sheen, washable. MPS: 45.

15. Floor Epoxy: Waterborne epoxy polyamide. MPS: 40.

16. Steel Bridge Epoxy Paint: High solids epoxy paint. MPS: 65.

17. Steel Bridge Polyurethane Paint: Acrylic polyurethane paint. MPS: 50.

B. Accessory Materials:

1. Shellac: ASTM D360, Type I, bleached, No. 4, cut with pure grain alcohol.

2. Thinner: As recommended by the manufacturer for the respective product.

3. Spackle or Putty: Standard commercial product manufactured for the purpose, thoroughly mixed to prevent the possibility of shrinkage. Use exterior grade for exterior Work. Spackle or putty shall be tinted toward finish color. Spackle or putty containing white lead will not be permitted for use on this Project.

PART 3 – EXECUTION

3.01 PREPARATION OF SURFACES

A. New Surfaces to be Painted:

1. Painting or finishing shall not be started until the surfaces to be painted or finished are in proper condition to accept, and assure the proper adhesion and functioning of, the specified painting system in accordance with the paint manufacturer's installation instructions and recommendations. Surfaces that cannot be properly prepared by the painter for finishing shall not be painted or finished until they are corrected. All surfaces to be painted shall be clean and dry.

2. Wood surfaces shall be sandpapered and dusted clean. Knots, pitch pockets, or sappy portions shall be sealed with clean shellac or knot sealer. Spackle or putty all nail holes, cracks, and other imperfections after first or prime coat with spackle or putty of color to match finish coat. Do not seal wood surfaces to receive stain or natural finish.

3. Concrete, masonry, stucco, and plaster shall be cleaned of form oils, efflorescence, chalk, dust, and dirt, and shall be thoroughly dry or dried before painting.

4. Holes, cracks, and other imperfections in surfaces to be painted shall be suitably primed and patched with a compound recommended by the manufacturer of the paint to be applied to these surfaces, and all areas to be painted shall be brought to true, even surfaces.

    a. Where cracks exist at transitions between existing and new materials, or in patched surfaces, such cracks shall be patched, and the patching material shall be feathered out and textured to match adjacent surfaces, so as to make the patched surface "invisible" after painting.

B. Existing Painted Surfaces to be Painted:

1. Concrete, Masonry, and Stucco Surfaces:

    a. Exterior concrete, masonry, and stucco surfaces shall be sandblasted by the "wet" sandblast method to remove all existing paint film from these surfaces.

        1) When "wet" sandblasting is not permitted by jurisdictional authority, surfaces shall be selectively power wire-brushed to remove loose and defective existing paint film. Edges of removed paint film shall be feathered out to conceal such edges in the finished work.

a) Surfaces not to be sandblasted shall be properly masked and otherwise protected to preclude damage to these surfaces.

b) Protection of the public and adjacent buildings from the residue of sandblasting operations shall be provided in accordance with the requirements of the jurisdictional authority.

2. Wood Surfaces: All wood surfaces shall be power sanded as required to remove all peeling, flaking, blistering, loose, or otherwise defective existing paint surfaces.

3. Metal Surfaces: Immediately preceding power-tool cleaning, pressure wash and rinse existing painted metal surfaces. Where access problems or the likelihood of damaging adjacent surfaces exist, wash and rinse. Existing painted metal surfaces shall be power-tool cleaned in accordance with SSPC-SP 3 to remove loose and defective paint surfaces, and then feathered smooth. Rust shall be completely removed. For steel bridges, clean in accordance with SSPC-SP 6/NACE No. 3 or SSPC-SP 10/NACE No. 2. Then solvent clean surfaces in accordance with SSPC-SP 1 to remove dust, and apply prime coat of Ferrous Metal Primer or Galvanized Metal Primer, as applicable, to existing surfaces as herein specified in Articles 3.04 and 3.05.

C. Hardware and Fixtures:

1. Hardware, hardware accessories, plates, lighting fixtures, and similar items in place shall be removed prior to painting and replaced upon completion of each space.

2. Heating and other equipment adjacent to walls shall be disconnected, using workers skilled in appropriate trades, and moved to permit wall surfaces to be painted. Following completion of painting, they shall be expertly replaced and reconnected.

D. Exposed Plumbing, Mechanical, and Electrical Items:

1. Items without factory finish such as conduits, pipes, ducts, grilles, registers, vents, access panels, and items of similar nature shall be finished to match adjacent wall and ceiling surfaces, unless otherwise directed. Paint visible surfaces behind vents, registers, and grilles flat black.

2. Wash exposed metal with solvent, prime, and paint as scheduled or specified. Spray paint wherever practicable. Do not paint concealed conduits, piping, and ducts.

3.02 PAINT PERFORMANCE AND FIELD QUALITY ASSURANCE

A. Painting shall be performed by skilled and experienced painters, working under the supervision of a capable supervisor. Materials shall be thinned only for proper workability and in compliance with the manufacturer’s specifications.

B. Paint material shall be evenly brushed or smoothly flowed on without runs or sagging, and free from drops, ridges, laps, and brush marks. Assure that all coats are thoroughly dry before applying succeeding coats. Sand surfaces between coats as necessary to produce a smooth finish and as may be required for adhesion of succeeding coats.

C. Priming or painting of wood will not be permitted on or in the station or building where concrete, masonry, or plaster is in the process of installation or application, or in the process of drying.

D. Putty, caulking, or spackle shall be applied after surface is primed and primer is dry.

E. Interior surfaces shall not be painted until concrete, masonry, and plaster surfaces in the station or building have completely cured and have stabilized moisture content in accordance with the paint manufacturer's recommendations.

F. Finish coats of paint shall not be applied on the interior of the station or building until the interior spaces are completely closed-in with windows and doors in place and glazed, until all interior wet and dust-producing work is complete and dry, and until the heating and ventilating system (or air-conditioning system) is in operation.

3.03 PAINT SYSTEMS

A. Provide three-coat work (unless otherwise specified), consisting of prime coat, intermediate coat, and finish coat, in texture and color as selected and approved by the Engineer.

B. Exterior paint systems are specified and identified herein by letter and interior paint systems by number, and the systems specified correspond to the finishes indicated on the Contract Drawings.

C. The herein specified paint systems indicate the minimum dry mil film thickness (MDFT) required for the particular paint system. Paint shall be applied at the manufacturer's recommended rate to achieve the proper MDFT specified. If a manufacturer normally does not utilize an intermediate coat in its paint system to achieve the specified MDFT, then the intermediate coat may be omitted.

3.04 EXTERIOR PAINTING

A. Paint System "A" - Paint Finish on Concrete, Masonry, and Stucco:

Prime Coat:	Masonry Surface Conditioner, tinted toward finish color.
Intermediate Coat:	Exterior Masonry Paint.
Finish Coat:	Exterior Masonry Paint.
MDFT:	6.

B. Paint System “B” - Paint Finish on Ferrous and Galvanized Metal:

Prime Coat:	For new ferrous metal: Field-apply Ferrous Metal Primer. For shop primed ferrous metal: Apply touchup primer. For galvanized metal: Galvanized Metal Primer touchup. For existing ferrous and galvanized metal: Rust-inhibitive primer as recommended by manufacturer of finish coats.
Intermediate Coat:	Heavy-Duty Gloss Enamel.
Finish Coat:	Heavy-Duty Gloss Enamel.
MDFT:	6.

C. Paint System “C” – Paint Finish on Wood:

Prime Coat:	Factory-primed (new surfaces). Exterior Wood Primer (existing surfaces).
Intermediate Coat:	Exterior House and Trim Paint.
Finish Coat:	Exterior House and Trim Paint.
MDFT:	7.

D. Paint System “D” – Paint Finish on Steel Bridges:

Prime Coat:	As specified in Article 2.04B in Section 05 12 00, Structural Steel Framing.
Intermediate Coat:	Steel Bridge Epoxy Paint.
Finish Coat:	Steel Bridge Polyurethane Paint.
MDFT:	11.

3.05 INTERIOR PAINTING

A. Paint Systems:

1. Paint System “1” - Flat Finish on Gypsum Wallboard:

Prime Coat:	P.V.A. Primer-Sealer, tinted toward finish color.
Intermediate Coat:	Interior Flat Latex Paint.
Finish Coat:	Interior Flat Latex Paint.
MDFT:	5.

2. Paint System “2” - Eggshell Finish on Gypsum Wallboard:

   Prime Coat: P.V.A. Primer-Sealer.

   Intermediate Coat: Alkyd Primer-Sealer, tinted toward finish color.

   Finish Coat: Eggshell Enamel.

   MDFT: 5.

3. Paint System “3” - Semi-Gloss Finish on Gypsum Wallboard:

   Prime Coat: P.V.A. Primer-Sealer.

   Intermediate Coat: Alkyd Primer-Sealer, tinted toward finish color.

   Finish Coat: Semi-Gloss Enamel.

   MDFT: 5.

4. Paint System “4” - Flat Finish on Concrete, Masonry, and Plaster:

   Prime Coat: Alkyd Primer-Sealer.

   Intermediate Coat: Interior Flat Latex Paint.

   Finish Coat: Interior Flat Latex Paint.

   MDFT: 5.

5. Paint System “5” - Eggshell Finish on Concrete, Masonry, and Plaster:

   Prime Coat: Alkyd Primer-Sealer.

   Intermediate Coat: Alkyd Primer-Sealer, tinted toward finish color.

   Finish Coat: Eggshell Enamel.

   MDFT: 5.

6. Paint System “6” - Semi-Gloss Finish on Concrete, Masonry, and Plaster:

   Prime Coat: Alkyd Primer-Sealer.

   Intermediate Coat: Alkyd Primer-Sealer, tinted toward finish color.

   Finish Coat: Semi-Gloss Enamel.

   MDFT: 5.

7. Paint System “7” - Paint Finish on Metal:

   Prime Coat: Factory Prime Coat and field-applied Ferrous Metal Primer or Galvanized Metal Primer touchup, as applicable.

   Intermediate Coat: Enamel Undercoat Enamel, tinted toward finish color.

   Finish Coat: Semi-Gloss Enamel.

   MDFT: 5.

8. Paint System “8” - Paint Finish on Woodwork and Trim:

   Prime Coat: Shop Prime Coat or Enamel Undercoat, as applicable.

   Intermediate Coat: Semi-Gloss Enamel, tinted toward finish color.

   Finish Coat: Semi-Gloss Enamel.

   MDFT: 5.

9. Paint System “9” - Paint Finish on Wood Shelves:

   Prime Coat: Enamel Undercoat.

   Finish Coat: Semi-Gloss Enamel.

   For all exposed wood shelves in closets, Janitor’s Rooms, and any other rooms or areas as indicated.

10. Paint System “10” - Paint Finish on Metal Handrails and Railings:

    Prime Coat: Factory Prime Coat and field-applied Ferrous or Galvanized Metal Primer touchup, as applicable.

    Intermediate Coat: Enamel Undercoat, tinted toward finish color.

    Finish Coat: Heavy-Duty Gloss Enamel.

    MDFT: 6.

11. Paint System “11” - Paint Finish on Concrete Floors, Steps, and Risers:

    Prime Coat: Floor Enamel, thinned as recommended by paint manufacturer.

    Finish Coat: Floor Enamel.

    MDFT: 4.5.

12. Paint System “12” - Paint Finish on Elevator Machine Rooms Floors and at Elevator Pits:

    Two Coats: Floor Epoxy.

    MDFT: 4 total.

3.06 CLEANING

A. Clean and retouch the work as necessary for a first-class job. All surfaces of the station or building and surrounding areas shall be left clean and neat in all respects, free from any paint spots, smears, smudges, or stain.

END OF SECTION 09 91 00

SECTION 09 96 33

GRAFFITI-RESISTANT COATINGS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Graffiti-resistant coatings.

1.02 MEASUREMENT AND PAYMENT

A. General: Graffiti-resistant coatings will not be measured separately for payment but will be paid for as part of the Contract lump sum price for Architectural Work.

1.03 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Samples: Submit samples of stone, masonry, and concrete (as proposed for the project), eight inches by 10 inches in size, of the prime and finish coatings.

C. Manufacturer's Data: Submit manufacturer's product data, including coatings' analysis and performance, and application instructions. Include manufacturer's recommended graffiti-removal procedures and products.

1.04 QUALITY ASSURANCE

A. VOC Regulations: Graffiti-resistant coatings shall comply with the Bay Area Air Quality Management District regulations governing permissible content of volatile organic compounds (VOC).

B. Manufacturer's Qualifications: Graffiti-resistant coatings shall be furnished by a manufacturer specializing in the manufacture of graffiti-resistant coatings.

C. Applicator's Qualifications: Graffiti-resistant coatings shall be applied by a licensed applicator approved by the manufacturer who furnishes the materials.

D. Coating Manufacturer's Approval and Job Service:

1. Contractor shall provide the graffiti-resistant coating manufacturer's field services for inspection and approval of coating applications.

2. The Contractor shall make all necessary arrangements with the coating manufacturer to provide on-site consultation and inspection services to ensure the proper application and completion of the graffiti-resistant coatings system.

3. The coating manufacturer's representative shall be present at the time any phase of the work is started. Graffiti-resistant coatings shall be applied only over surfaces previously approved by the coating manufacturer's representative.

1.05 MOCK-UP

A. Before beginning coatings' applications, provide sample mockup applications, measuring three feet by four feet each, at inconspicuous locations, on each different substrate. Coordinate mockup location with the Engineer for the Engineer's review and testing.

1.06 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to the project site in new, unopened containers with the following information: manufacturer's name, product data, and application instructions.

B. Store materials and equipment in a properly ventilated, designated storage space on the site. Temperature of storage area shall not be less than 45 degrees Fahrenheit and shall not exceed 90 degrees Fahrenheit.

1.07 SITE CONDITIONS

A. Apply coatings only when the temperature of surfaces to receive coatings and surrounding air temperatures are between 50 degrees and 90 degrees Fahrenheit, unless otherwise permitted by the coating manufacturer's printed instructions.

B. Do not apply coatings during periods of fog, mist, and rain, or when rain is imminent.

PART 2 – PRODUCTS

2.01 GRAFFITI-RESISTANT COATINGS

A. Graffiti-resistant coatings, base or prime coat and finish coats, shall be a two-component, polymer-based, non-sacrificial product. The finished coating shall be stable, colorless, transparent, low sheen (satin or flat), water soluble product.

B. Coatings shall be weather and rain resistant, abrasive resistant, peel resistant, ultra-violet resistant, non-yellowing, and shall permit moisture vapor relief.

C. Graffiti-resistant coatings shall have the capability of having all types of paints and graffiti materials completely removed without damaging the uncoated surfaces to which they are applied. Coatings which require re-application in areas which have been repeated cleaned will be acceptable. Re-application shall not require removal of coating.

D. Products required to remove graffiti from the coating shall be non-toxic and shall comply with the herein referenced VOC Regulations. Removal of graffiti shall cause no damage or change in the appearance of the treated surface.

E. Coatings shall be products manufactured specifically for protection of surfaces against graffiti vandalism. Products require review and approval by the Engineer before they may be purchased for use in the work.

PART 3 – EXECUTION

3.01 CONDITION OF SUBSTRATE

A. Examine the areas and conditions under which graffiti-resistant coating work is to be performed.

B. Do not apply coating system over surface contaminants, such as dust, dirt, form oils, and loose substrate.

C. Verify pH of concrete or masonry substrate is within coating manufacturer's requirements using test method acceptable to coating's manufacturer. Any action required to ensure pH of substrate is acceptable, including delaying application until substrate has further cured, shall be the responsibility of the Contractor.

3.02 COATINGS PREPARATION AND MIXING

A. Prepare and mix materials in accordance with the coating manufacturer's instructions and recommendations.

B. Remove any skins that form on surface of material prior to moving containers, mixing, or using.

C. Stir materials before application to produce a mixture of uniform density, and stir as required during application. Do not stir surface film into material. Remove film and, if necessary, strain material before using.

3.03 APPLICATION

A. Prepare surfaces and apply coatings in accordance with the coating manufacturer's application instructions and recommendations. Apply coatings in thickness and sequence of coats as recommended by the coating manufacturer.

END OF SECTION 09 96 33

SECTION 10 14 27

POST AND PANEL WAYFINDING SYSTEM

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Signage and information system (i.e. wayfinding kiosk) which contains map with stop and route information to facilitate connection between transit operators.

1.02 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for post and panel wayfinding system will be either by the lump-sum method or by the unit-price method as determined by the listing of the bid item for post and panel wayfinding system indicated in the Bid Schedule of the Bid Form.

B. Lump Sum: If the Bid Schedule indicates a lump sum for post and panel wayfinding system, the lump-sum method of measurement and payment will be in accordance with Section 01 20 00, Price and Payment Procedures, Article 1.03.

C. Unit Price: If the Bid Schedule indicates a unit price for post and panel wayfinding system, the unit-price method of measurement and payment will be as follows:

1. Measurement:

    a. Post and panel wayfinding system will be measured for payment by the individual unit (each), installed in place.

2. Payment: Post and panel wayfinding system will be paid for at the indicated Contract unit prices for the computed quantities as determined by the measurement method specified in Article 1.02.C.1, herein.

1.03 REFERENCES

A. National Electrical Manufacturers Association (NEMA)

1.04 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data and Samples; for submittal requirements and procedures.

B. Submit shop drawings and the manufacturer’s technical literature. Include the manufacturer’s toll-free telephone number for product support.

C. Submit half-size laser print outs of graphics for each kiosk face for approval.

D. Submit structural calculations including wind loadings prepared by a Professional Engineer currently registered in the State of California. Include structural calculations for each unit's anchorage to ground, including anchor bolts, footing, and base plate, as applicable. The pipe-to-base plate weld shall develop the complete strength of the pipe where connected to the plate (such as a properly executed Complete Joint Penetration weld would do).

E. Qualifications: Refer to Article 1.05 entitled, "Quality Assurance" herein for qualification requirements.

1.05 QUALITY ASSURANCE

A. Contractor's Professional Engineer's Qualifications

1. Upon the Engineer's request, provide a reference list with client contact information. List shall show that the engineer has a record of successful experience providing engineering services for installations similar in design and scope to the work of this Section.

B. Manufacturer and Fabricator Qualifications

1. Minimum five years experience in the fabrication of post and panel wayfinding systems.

2. Provide a project reference list and photos of public or commercial exterior projects currently using items or signage and information systems supplied by the manufacturer.

1.06 DELIVERY, STORAGE AND HANDLING

A. Handle products in accordance with the manufacturer's instructions. Store in a dry, secure location, protected against direct sunlight and excessive heat.

1.07 WARRANTY

A. In addition to the Guaranty required in the General Conditions, provide manufacturer's standard warranty.

1.08 MAINTENANCE TOOLS

A. Provide a minimum of three keys for each kiosk to the Engineer.

PART 2 – PRODUCTS

2.01 GENERAL

A. Post-mounted, double-sided signage and information system with signage elements consisting of curved face panels attached to a rigid internal structure.

1. Suitable for all-weather outdoor use.

2. At the Contractor's option, the kiosk may be fabricated from stainless steel in lieu of aluminum shown on the Contract drawings. Where stainless steel is utilized in lieu of aluminum for the exterior of a unit, it shall be stainless steel shall Type 316.

3. Provide graphics on both sides of the unit. Refer to article entitled "Artwork" herein.

    a. Provide screen-printed graphics and applied vinyl graphics at the top portion of both sides of the exterior of the unit. Other methods of applying graphics which meet or exceed the specified method in weather, chemical, graffiti, and ultraviolet light resistance may be acceptable to the Engineer.

    b. Provide a graphics sheet insert for the inside of each unit behind each window.

4. Provide a cutout with a clear polycarbonate window, minimum 0.125 inch thick, and an insert carrier for the graphics display on each side of each signage assembly.

    a. Panels with window cutouts shall include continuous stainless steel hinges and locking mechanisms for access to the interior.

    b. The window shall be retained in a window opening using slots provided in the curbed face panel's edge profile, or by other means per approved shop drawings. Secure window with studs and nuts.

    c. Provide a minimum 0.06 inch thick aluminum graphic panel, powder coated white to accept the graphic sheet insert.

    d. Locking Mechanism and Keying: Locks shall be keyed compression locks; with tubular keys. Combination locks are not acceptable. Locks on a single unit shall be keyed the same. Other requirements regarding keying shall be as required by the Engineer. Lock shall include the following features:

        1) Size: Small, 1.47 inches compressed.

        2) Stainless steel latch body made by metal injection molding, Type 316.

        3) Adjustable grip.

        4) Suitable for NEMA 4/IP65 applications.

        5) Includes gasket.

6) Single turn latching and compressing action. Locks snugly against gasket in locked position.

e. Anti-Graffiti Film: optically clear; easy to remove and replace; 4 mil protective film; Solar Gard Graffitigard, 3M Anti-Graffiti 4, or equal. Film shall act as sacrificial barrier to protect window from paint, key scratches, marking, and acid-etching.

5. Provide Type 316 stainless steel base plates and anchor bolts. The pole welded to the base plate shall be Type 316 stainless steel.

B. Curved Face Panels

1. Material: Aluminum, 0.125 inch minimum thickness.

2. Provide curved face panels. Edges shall be internal and completely concealed from view in the assembled signage unit.

C. Internal Structure and End Plates

1. Provide an internal structure sufficient to support the sides of the kiosk and end and face panels and to ensure that the kiosk unit remains centered and secured to pole. The internal structure shall be a one piece extrusion or welded module.

2. Center Support Plate or Plates, as Applicable: Aluminum plate, minimum 0.25 inch thickness.

3. End plates: Aluminum plate, thickness as determined by structural design.

D. Bird Control Wire

The bird barrier shall be designed for all bird species consisting of wire spikes on a base strip, 4 inches high, 4 inches wide, consisting of no less than 120 wire points per foot, providing full 180-degree wire coverage.

1. Wire Spikes: Stainless steel, 0.041 inch diameter, full-hard spring temper, 250,000 lbs./in. tensile strength. Base strip: Stainless steel, 0.25 inch wide x 0.02 inch thick, fully annealed for flexibility and surface shape memory. Similar stainless steel systems may be acceptable subject to the approval of the Engineer.

E. Weatherproofing: Provide gasketing for exterior use. Provide for ventilation of the interior and weep holes. Provide insect screens at weep holes and vents.

F. Security: Provide tamper-resistant stainless steel security screws to prevent unauthorized removal of curved face panels. Security screws shall be countersunk flush with the frame’s formed or fabricated edge. Welded construction may be utilized in lieu of external security fasteners.

G. Finish of Exposed Surfaces, Including Curved Face Panels, Sides, End Plates, Mounting Pole, and Base Plate: Manufacturer's graffiti-resistant polyester powder coat with anti-graffiti coating.

1. Colors: As indicated in the Contract Documents.

2.02 FABRICATION

A. Factory assemble the units and apply finishes and graphics in accordance with the manufacturer's standards and approved shop drawings.

B. Weld the post to the base plate: The base plate shall be perpendicular to the post within plus or minus one degree.

2.03 ARTWORK

A. Unless otherwise specified in the Contract Specifications, the Engineer will furnish electronic files showing the required logos, fonts, and layout of typical sign for use by the Contractor. The Contractor shall furnish graphic design services to design each sign face. The software of the artwork file will be as designated in the Contract Specifications.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Verify that substrates are stable and capable of supporting the weight of signage units.

B. Verify that substrates have been adequately prepared to securely anchor signage units.

3.02 PREPARATION

A. Clean surfaces thoroughly prior to installation.

B. Protect surrounding finishes and fixtures from damage by work of this Section.

3.03 INSTALLATION

A. Install in accordance with the manufacturer's installation instructions.

B. Install in accordance with details as shown in the Contract Drawings and approved shop drawings.

3.04 CLEANING AND PROTECTION

A. Clean exposed surfaces in accordance with the manufacturer's instructions.

B. Protect exposed surfaces from damage by subsequent construction.

END OF SECTION 10 14 27

SECTION 10 14 29

STATION IDENTIFICATION PYLONS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Stainless steel station identification (ID) pylons.

1.02 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for station identification pylons will be either by the lump-sum method or by the unit-price method as determined by the listing of the bid item for station identification pylon indicated in the Bid Schedule of the Bid Form.

B. Lump Sum: If the Bid Schedule indicates a lump sum for station identification pylons, the lump-sum method of measurement and payment will be in accordance with Section 01 20 00, Price and Payment Procedures, Article 1.0.3.

C. Unit Price: If the Bid Schedule indicates a unit price for station identification pylons, the unit-price method of measurement and payment will be as follows:

1. Measurement:

    a. Station identification pylons will be measured for payment by the individual unit (each), installed in place.

2. Payment: Station identification pylons will be paid for at the indicated Contract unit prices for the computed quantities as determined by the measurement method specified in Article 1.02.C.1, herein.

1.03 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM A240/ A240M — Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.

2. ASTM A269/ A269M — Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service

3. ASTM A276/ A276M — Standard Specification for Stainless Steel Bars and Shapes

4. ASTM A312/ A312M — Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipe

5. ASTM A554 — Standard Specification for Welded Stainless Steel Mechanical Tubing

6. ASTM A743/ A743M — Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application

7. ASTM A968/ A968M — Standard Specification for Chromium, Chromium-Nickel, and Silicon Alloy Steel Bars and Shapes for Corrosion and Heat-Resisting Service

B. National Association of Architectural Metal Manufacturers (NAAMM):

1. AMP 500 — Metal Finishes Manual

C. Specialty Steel Industry of North America (SSINA):

1. Stainless Steel Fasteners – Designer Handbook

D. American National Standards Institute (ANSI)/American Welding Society (AWS):

1. ANSI/ AWS D10.4 — Recommended Practices for Welding Austenitic Chromium-Nickel Stainless Steel Piping and Tubing

1.04 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures; and Section 01 33 23, Shop Drawings, Product Data, and Samples; for submittal requirements and procedures.

B. Shop Drawings: Submit detailed Shop Drawings of pylons, showing dimensions, details of fabrication and installation. Shop drawings shall indicate how lighting elements are accessed for service. Indicate materials, profiles, joinery, finishes, fasteners, anchorages and accessories. Indicate welded connections by AWS symbols.

C. Product Data: Submit manufacturers' product data of manufactured items including translucent materials and vinyl films.

D. Samples: Submit samples of the following:

1. Stainless steel sample showing the proposed finish. Sample shall be a minimum 24 inches long by eight inches wide. Prepare samples on metal of the same alloy and thickness to be used in the Work.

2. Translucent acrylic material with sample vinyl letter and proposed blue translucent material.

3. Proposed blue translucent material: Submit samples of the full range of manufacturer's blue colors.

E. Submit structural calculations and details for pylons prepared, signed, and sealed by a Professional Engineer currently registered in the State of California. Include structural calculations for entire pylon and its anchorage assembly. Provide calculations for loadings and stresses. Structural calculations shall include anchorage to ground or other substrate, including anchor bolts, assemblies, foundation, and base plate, as applicable. Include seismic and wind loadings. Include calculations for each pylon location if required to suit individual site characteristics.

F. Qualifications: Refer to Article entitled “Quality Assurance” herein for qualification requirements.

G. Mill Test Reports:

1. Submit certified mill tests reports of stainless steel materials, covering chemical analysis and physical properties of each heat of steel from which the material for stainless steel will be furnished, in conformance with the hereinafter specified ASTM Specifications.

1.05 QUALITY ASSURANCE

A. Stainless steel work shall conform to the quality requirements of the herein referenced Specialty Steel Industry of North America, “Designer Handbook: series standards.

B. Iron Contamination (Rust): Stainless steel with iron contamination will not be accepted. Dies for forming stainless steel components shall be stainless steel or chrome-plated to prevent embedment of minute iron particles. All stainless steel work shall be polished and cleaned after fabrication and installation to prevent rust susceptibility.

C. Material Certifications: Steel materials which are not properly certified as conforming to specified ASTM Specifications will be rejected.

D. Contractor’s Professional Engineer’s Qualifications: The engineer responsible for structural design required under this Section shall have a record of successful experience providing engineering services for installations similar in design and scope to the work of this Section. Upon the Engineer’s request, provide a reference list with client contact information.

E. Manufacturer and Fabricator Qualifications:

1. Minimum five years’ experience in the fabricating of similar stainless steel work to that specified for similar projects.

2. Provide a project reference list and photos of public or commercial exterior projects with stainless steel work currently in use of similar type and size by manufacturer.

F. Pre-Installation Conference: Conduct conference at the Jobsite prior to the installation of the first pylon. Conference shall be attended by the Contractor, and Contractor's fabricator, electrician, and installer and the Engineer.

1.06 STORAGE, DELIVERY, AND HANDLING

A. Store pylons and accessories in clean, dry location, away from uncured concrete and masonry.

B. If pylons are protected with a protective covering:

1. Ensure that protective coverings do not damage items being protected. Provide air circulation under coverings when necessary to prevent damage to pylons.

2. Restore protective coverings which have been damaged during shipment.

C. Minimize handling of pylons at Jobsite; exercise care and prevent damage including damage to finishes.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Base plate assemblies, posts, pylons, framing connectors, anchors, and other components shall be stainless steel with the exception of those items specifically required to be fabricated from other materials.

B. Stainless Steel: Provide austenitic stainless steel Type 316 complying with the following requirements:

1. Tubing: ASTM A554 or ASTM A269/A269M.

2. Pipe: ASTM A312/A312M.

3. Plate: ASTM A240/A240M or ASTM A968/A968M.

4. Bar Stock: ASTM A276/A276M.

5. Castings: ASTM A743/A273M, Grade CF 8 or CF 20

C. Fasteners: Comply also with applicable requirements of SSINA's "Stainless Steel Fasteners." Of same basic stainless steel alloy as fastened metal, unless otherwise indicated. Do not use metals which are corrosive or otherwise incompatible with metals joined. Anchors and fasteners shall be tamper-resistant where exposed.

D. Anchors and Inserts: Provide stainless steel anchors of type and size required for type of loading and installation condition shown, as required by the Contractor's engineer, unless otherwise indicated.

E. Grout: Refer to Section 03 61 11, Non-Shrink Grout, for requirements.

2.02 PRODUCTS

A. Photosensor: As proposed by the Contractor and approved by the Engineer.

B. Bird Wire: Refer to Section 10 81 13, Bird Control Devices.

C. Applied Vinyl Film: 3M Scotchcal Translucent Graphic Film Series 3630 or equal, cast vinyl film for internally illuminated signs approved by film manufacturer for application to substrate. Film shall have matte surface finish with uniform color in both reflected and transmitted light; clear, permanent, pressure-sensitive adhesive; and a translucent synthetic liner.

1. Thickness of film without adhesive: 2 mils.
2. Overall thickness of film: 3 to 4 mils.
3. Tensile strength: 5 pounds per inch at 73 degrees Fahrenheit.
4. Chemical resistance: Resistant to mild alkalis, mild acids, and salt. Film shall be suitable for both interior and exterior use.

D. Lights: LED consisting of a LED luminaire assembly, LED driver, and mounting hardware.

1. Light Fixtures: OSRAM LED Chain Signage Modules BB03MA-W4F-765, or equal, with the following as described below:
    a. Rating: 67 Lumen per module and 135 Lumen per foot.
    b. Beam angle: 120 degrees.
    c. Correlated Color Temperature (CCT): Minimum 6500K.
    d. Lifespan: A minimum of 50,000 operating hours before reaching the L70 lumen output degradations point without catastrophic failure.
    e. Fixture shall be UL listed.
    f. Fastening: Peel and stick tape on back of each module and industrial silicone on sides as indicated on the Contract Drawings.
2. Power Supply: France LED-1260PS, or equal with the following features:
    a. Operating input voltage: 120 VAC to 277 VAC (plus or minus 10 percent).
    b. Operating output voltage: 12 VDC, 5 Amps, 60 Watts.
    c. Operating temperature: 20 to 50 degrees Celsius.
    d. Power supply shall have minimum IP66 rating for wet, damp, or dry location use.
    e. Power supply shall be UL listed.
    f. Warranty: 5 years.

E. Acrylic Sheet: 0.236 inch thick, UV resistant, satin texture, optimum light diffusion, extruded, scratch resistant surface. Light diffusing beads shall be evenly distributed through material. Texture shall be retained after thermoforming.

1. Colors: Translucent white and translucent “BART” blue

2.03 DESIGN CRITERIA

A. Contract Drawings establish the design intent, product dimensions, materials, minimum material thickness, concealment of fastenings, and standard of quality. It is the intention of the Contract Documents to rely on the Contractor to finalize details subject to the Engineer’s approval of the shop drawings. The Contractor shall finalize details subject to its construction technique such as those predicated on machinery, experience, and shop practices.

B. Provide concealed fasteners for interconnection of pylon components and for their attachment to other work except where otherwise indicated or when exposed fasteners are unavoidable.

C. Design pylons to accommodate construction tolerances and deflection of structural members.

D. Detail pylons to permit structural and thermal movement of components without buckling, undue stress on fasteners, or other detrimental effects.

E. Allow for thermal movement resulting from the following maximum change (range) in ambient temperature, in the design, fabrication, and installation of pylons to prevent buckling, opening up of joints and overstressing of welds and fasteners. Base design calculations on actual surface temperatures of metals due to both solar heat gain and night time sky heat loss.

1. Temperature Change (Range): 100 degrees Fahrenheit, (55.5 degrees Celsius) or as recommended by fabricator and approved by the engineer.

F. Provide adjustment to accommodate misalignment of structure without distortion or damage.

G. Provide vandal-resistant fasteners and other details.

H. Detail pylons to accommodate replacement of lightening elements and acrylic lens (panels).

I. Detail to accommodate removal of pylon for purposes of its relocation or repair.

J. No part of frame or other internal parts shall project into the light parth or otherwise cast shadows onto the translucent portions of the pylons. Lamps shall be spaced and arranged so that the illuminated portions of the pylons have uniform light intensity.

2.04 FABRICATION – GENERAL

A. Shop fabricate, finish, and assemble pylons to the greatest extent possible.

B. Refer to Section 05 05 22, Metal Welding. Comply with AWS for recommended practices in shop welding. Stainless steel welded connections shall be made in accordance with applicable requirements of ANSI/AWS D10.4. Clean exposed welded joints of all welding flux, and dress on all exposed and contact surfaces. Welded joints shall be ground and dressed smooth to match adjacent surfaces and specified finish. Welded joints shall be ground and dressed so that the shape and profile of the items welded is maintained and so that the weld seam is invisible in the finished work. Ends shall be closed with matching material.

C. Provide welds behind finished surfaces without distortion or discoloration of exposed side.

D. Welded Connections: Fabricate stainless steel pylon for the interconnections of members by welding where shown.

E. Fabricate stainless steel pylon from hollow structural section (HSS) steel.

F. Non-Welded Connections: Fabricate stainless steel pylon for interconnection of members by means of concealed mechanical fasteners and fittings where shown. Fabricate members and fittings to produce flush, smooth, rigid, hairline joints.

G. Finish: Satin, Non-directional, (orbital) polish, matte surface finish, without grain. Finish shall match approved BART finish samples and existing pylons. Process to achieve finish is as follows:

1. Starting with 316 Stainless plates you must have a #20 RA finish applied. (This is the closest thing to a NAAMM #6 finish in the process).

2. After fabrication of “Tube” the following steps are needed:

    a. Grind all surfaces with rotary finisher using 150 grit disc to smooth welds.

    b. Grind all surfaces with rotary finisher using 120 grit disc.

    c. Grind all surfaces with rotary finisher using 220 grit disc.

    d. DA random orbital sander on all surfaces using 120 grit paper.

    e. DA random orbital sander on all surfaces using 80 grit paper.

    f. DA all surfaces with heavy fiber Scotch bright until even “scratch” is achieved.

    g. After finishing all surfaces passivate entire pylon.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install pylons as indicated and in accordance with the approved Shop Drawings, using workers skilled and experienced in the installation of the type of work involved.

B. Set products accurately in location, alignment and elevation, plumb, level and true measured from established lines and levels. Provide temporary bracing or anchors in formwork for items which are to be built into concrete or similar construction.

C. Fit exposed connections accurately together to form tight, hairline joints or, where indicated, with uniform reveals and spaces as shown. Where cutting, welding and grinding are required for proper fitting and jointing of stainless steel, restore finishes to eliminate any evidence of such corrective work.

D. Do not cut or abrade finishes which cannot be completely restored in the field. Return items with such finishes to the shop for required alterations, followed by complete refinishing or provide new units as required.

E. If pylons are protected with a protective covering:

1. Restore protective coverings which have been damaged during shipment or installation of the work. Remove protective coverings only when there is no possibility of damage from other work yet to be performed at the same location.

2. Retain protective coverings intact and remove simultaneously from similarly finished items to preclude non-uniform weathering and discoloration.

3. Remove protective coverings at the time of Substantial Completion or earlier with the approval of the Engineer.

F. Field welding, where required, shall conform to requirements specified herein for shop welding under “Fabrication.” All welds shall be ground and polished smooth to match adjacent finish surfaces.

3.02 CLEANING OF STAINLESS STEEL

A. All stainless steelwork shall be cleaned of all dirt, dust, oil and grease, fingerprints, atmospheric and aqueous corrosion, and iron contamination, rinsed with clear water, and then polished before the Engineer’s final inspection that establishes Substantial Completion of the Contract.

B. The cleaning method shall be the mildest treatment necessary for the problem.

C. Corrosion shall be removed by scouring lightly with an abrasive cleaner, rubbing in the direction of the finish grain of the metal. In cases of extreme discoloration, use scouring sponges or steel wool, made only from stainless steel, and then rinsed thoroughly with clean water.

D. Iron contamination shall be removed by passivation, as chemical cleaning method involving the use of nitric acid. This cleaning method shall be performed in the shop only, unless no other treatment at the site is successful. Passivation treatment at the site shall be performed under the continuous supervision of the stainless steel fabricator, employing all required safety precautions and protection of adjacent surfaces.

E. Weldments may require additional fine grinding to remove corrosion or iron contamination if no other cleaning method is successful.

F. All cleaned and rinsed stainless steelwork shall be dried with clean towels and then polished by buffing. If a dull or satin finish is indicated, then buff only enough to remove any remaining residue.

END OF SECTION 10 14 29

SECTION 10 14 33

ILLUMINATED CABINET SIGNAGE

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Exterior and interior illuminated overhead hanging, beam-mounted, post mounted and wall-mounted signs.

B. Exterior and interior non-illuminated wall-mounted and post-mounted signs.

1.02 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for overhead illuminated cabinet signs including info cubes of various sizes, number of sides/faces, and mounting configurations will be either by the lump-sum method or by the unit-price method as determined by the listing of the bid item for illuminated cabinet signage indicated in the Bid Schedule of the Bid Form.

B. Lump Sum: If the Bid Schedule indicates a lump sum for overhead illuminated cabinet signs, the lump-sum method of measurement and payment will be in accordance with Section 01 20 00, Price and Payment Procedures, Article 1.03.

C. Unit Price: If the Bid Schedule indicates a unit price for overhead illuminated cabinet signs, the unit-price method of measurement and payment will be as follows:

1. Measurement:

   a. Overhead illuminated cabinet signs will be measured for payment by the individual unit (each), installed in place.

2. Payment: Overhead illuminated cabinet signs will be paid for at the indicated Contract unit prices for the computed quantities as determined by the measurement method specified in Article 1.02.C.1, herein.

1.03 REFERENCES

A. American Architectural Manufacturers Association (AMAA):

1. AMAA 2603 Voluntary Specification, Performance Requirements and Test Procedures for Pigmented Organic Coatings on Aluminum Extrusions and Panels

B. Americans with Disabilities (ADA)

C. Association Connecting Electronics Industries (IPC)

D. ASTM International (ASTM):

1. ASTM A123/ A123M	Standard Specification for Zinc (Hot-Dip Galvanized) Iron and Coatings on Steel Products
2. ASTM A153/ A153M	Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
3. ASTM B209	Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
4. ASTM B221	Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes

E. Code of Federal Regulations (CFR):

1. 47 CFR Part 15	Radio Frequency Devices

F. National Fire Protection Association (NFPA):

1. NFPA 70	National Electrical Code (NEC)

G. Society for Protective Coatings (SSPC):

1. SSPC SP6/ NACE No. 3	Commercial Blast Cleaning

H. Underwriters Laboratories (UL):

1. UL 48	Standard for Electric Signs

1.04 SUBMITTALS

A. General: Refer to Specifications Section 01 33 00, Submittal Procedures, and 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Product Data: For each type of product indicated.

C. Shop Drawings: Include fabrication and installation details for signs and mounting devices showing mounting heights, locations of supports and accessories. Submit the following:

1. Message list, typestyles, graphic elements, and layout for each sign.
2. Mounting heights, locations of supports and accessories.
3. Half-size laser print outs of each sign face.
4. Wiring diagrams: Power and control wiring.

D. Samples: Submit the following samples for verification:

1. Corner of aluminum frame showing mitered and welded corner with finish, each leg of corner a minimum of 8 inches long.

2. Acrylic sheet, 8 by 10 inches.

3. Acrylic sheet with translucent and opaque finish; for both interior and exterior, as applicable, 8 by 10 inches.

4. Samples of translucent film in each color required.

E. Prototype: As many as one prototype for each sign type, upon Engineer's request.

F. Calculations: Submit structural calculations including seismic, wind, and vibration loadings prepared, signed and sealed by a professional engineer registered in California. Include structural calculations for anchorage. Calculations that were submitted and approved with the Shop Drawing submittals shall not be re-submitted under this Section.

G. Qualifications: Refer to Article entitled "Quality Assurance" herein.

1.05 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with applicable provisions in Americans with Disabilities Act and California Building Code.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Fabricator Qualifications:

1. Minimum 5 years experience in fabrication of illuminated cabinet signage.

2. Submit a project reference list and photos of public or commercial exterior projects currently using items or signage and information systems supplies by the manufacturer.

D. Powder-Coating Applicator Qualifications: A firm experienced in successfully applying powder coatings of type indicated and employing competent control personnel to conduct continuing, effective quality-control program to ensure compliance with requirements.

E. Prototype: The Engineer may require prototypes of any or all sign types. Upon Engineer's request, build prototype of each specific sign type requested to demonstrate aesthetic effects and verify and set quality standards for fabrication and installation. Modify prototype and Shop Drawings as required by Engineer in order to obtain Engineer's approval. Approved prototype may become part of the completed Work with Engineer's written permission. Either deliver prototype to location

indicated by Engineer or make available for Engineer's review at Contractor or fabricator's facility within 50 miles from Oakland, CA.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle materials in accordance with Section 01 60 00, Product Requirements and Manufacturer's instructions. Store in dry, secure location, protected against direct sunlight and excessive heat.

1.07 WARRANTY

A. In addition to the guaranty required in the General Conditions, provide manufacturer's standard warranty.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Aluminum Sheet and Plate: ASTM B209, alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated, and with at least the strength and durability properties of Alloy 5005-H32.

B. Aluminum Extrusions: ASTM B221, alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated, and with at least the strength and durability properties of Alloy 6063-T5.

C. Acrylic Sheet: Plaskolite Optix, 7328 white polyfilm, 0.236 inch thick, translucent white, as manufactured by Plaskolite Inc. or equal. Acrylic sheet shall be UV resistant, satin texture, extruded, impact- and scratch- resistant surface.

D. Applied Vinyl: 3M Scotchcal Translucent Graphic Film Series 3630 or equal, cast vinyl film for internally illuminated signs approved by film manufacturer for application to substrate. Film shall have matte surface finish with uniform color in both reflected and transmitted light; clear, permanent, pressure- sensitive adhesive; and a translucent synthetic liner. Thickness of film without adhesive: 2 mils. Overall thickness of film: 3 to 4 mils. Tensile strength: 5 pounds/inch at 73 degrees Fahrenheit. Chemical resistance: Resists mild alkalis, mild acids, and salt. Film shall be suitable for both interior and exterior use, however, refer to Article entitled "Cabinet Signs" herein for an explanation regarding where this film shall be used.

E. Applied Vinyl with Protective Top Coat: 3M Scotchcal Translucent Graphic Film Series 3632 GPS or equal. For detailed specifications for this film, refer to "Applied Vinyl" herein for Series 3630 with the addition of protective top coat with low-sheen finish. Refer to Article entitled "Cabinet Signs" for an explanation regarding where this film shall be used.

F. Paint: Multi-component opaque paint material consisting of pigmented base and activator; UV resistant; satin sheen; Matthews Acrylic Polyurethane or equal. Use primer and undercoats as recommended in writing by paint manufacturer for specific substrate.

G. Gaskets and Seals: Provide neoprene gaskets as indicated on the Contract Drawings.

H. Bird Control Components:

1. Posts, springs, and accessories: Fabricated from Type 316 stainless steel.

2. Wire: Braided stainless steel wire coated with ultraviolet stabilized nylon coating.

2.02 CABINET SIGNS

A. Brackets: Fabricate brackets and fittings for wall-mounted signs from extruded aluminum to suit cabinet sign construction and mounting conditions indicated. Fabricate pendants for overhead-mounted signs as indicated on the Contract Drawings. Factory paint or powder coat brackets in color indicated. Powder coat pendants and related hardware as indicated on the Contract Drawings.

B. Cabinet Sign Frames: Extruded-aluminum frames mitered with concealed anchors and welded.

C. Panel Material: White translucent acrylic sheet.

D. Artwork Materials:

1. Interior Sign Panels: Translucent and opaque areas of interior sign panels shall be applied vinyl.

2. Exterior Sign Panels:

a. Opaque areas of exterior sign panels shall be painted.

b. Translucent portions of exterior signs shall be applied vinyl with protective top coat.

2.03 ACCESSORIES

A. Anchors and Inserts: Provide stainless steel anchorages.

B. Design and selection of anchors for overhead applications and subjected to sustained tensile loads where failure of the anchor could result in risk to life or limb shall comply with the following requirements: Such anchors shall be embedded in confined concrete. Length of embedment in unconfined concrete shall not be considered effective embedment length. Use of adhesive anchors is prohibited.

2.04 ELECTRICAL

A. The light fixture shall be LED and consist of a luminaire assembly, driver, and mounting hardware.

1. Light Fixtures: OSRAM LED Chain Signage Modules BB03MA-W4F-765 or equal, with the following as described below:

   a. The luminaire shall be rated 67 lumen per module and 135 lumen per foot. Beam angle: 120 degrees.

   b. Correlated Color Temperature (CCT): Minimum 6500K.

   c. Modules shall be waterproof design, minimum IP66.

   d. Longevity: A minimum of 50,000 operating hours before reaching the L70 lumen output degradations point without catastrophic failure.

   e. Fixture shall be UL listed.

   f. Fastening: Peel and stick tape on back of module and industrial silicone on sides as indicated on the Contract Drawings.

2. Low voltage power supply for signs with two lines or more of graphic text: France LED-1260PS or equal with the following features:

   a. Operating input voltage: 120 VAC to 277 VAC (plus or minus 10 percent).

   b. Operating output voltage: 12 VDC, 5 Amps, 60 Watts.

   c. Operating temperature: -20 degrees Celsius to 50 degrees Celsius.

   d. Shall have minimum IP66 rating for wet, damp or dry location use.

   e. Fixture shall be UL listed.

   f. Warranty: 5 years.

3. Low voltage power supply for signs with one line of graphic text: Magtech LED-LP1020-12 or equal with the following features:

   a. Operating input voltage: 120 VAC to 277 VAC (plus or minus 10 percent).

   b. Operating output voltage: 12 VDC, 5 Amps, 60 Watts.

   c. Operating temperature: -20 degrees Celsius to 50 degrees Celsius.

   d. Shall have minimum IP66 rating for wet, damp or dry location use.

   e. Fixture shall be UL listed.

   f. Warranty: 5 years.

B. Complete Sign Cabinets: Sign cabinets shall UL labeled in accordance with UL 48.

2.05 FABRICATION

A. General: Provide signs of configurations indicated.

1. Welded Connections: Comply with applicable AWS standards metal and weld type for recommended practices in shop welding. Provide welds behind finished surfaces without distortion or discoloration of exposed side. Clean exposed welded surfaces of welding flux and dress exposed and contact surfaces.

2. Mill joints to tight, hairline fit. Form joints exposed to exclude water penetration. Form joints to eliminate light leaks. Provide gasketing and seals where indicated on the Contract Drawings and as required to ensure weather-tight assembly.

3. Conceal fasteners if possible; otherwise, locate fasteners where they will be inconspicuous.

4. Each sign face shall be fabricated from a single sheet of acrylic; no splices or seams are permitted.

B. Shop assembled units and apply finishes and graphics in accordance with the Contract Drawings, manufacturer's standards, and approved Shop Drawings.

2.06 ARTWORK

A. The Contractor shall furnish a graphic layout in the form of electronic files showing the required logos, fonts, and layout of typical sign for use by the Contractor. The Contractor shall develop and complete artwork for each sign panel as indicated.

2.07 ALUMINUM FINISHES

A. Paint or powder-coat finish, at fabricator's option.

B. Paint Finish: Acrylic polyurethane paint as specified herein.

C. Powder-Coat Finish: AAMA 2603 except with a minimum dry film thickness of 1.5 mils. Comply with coating manufacturer's written instructions for cleaning, conversion coating, and applying and baking finish.

D. Color and Gloss:

1. Exterior Box and Support Components: Black, satin gloss.

2. Interior of Box: White, reflective.

2.08 STEEL FINISHES

A. Galvanizing: Hot-dip galvanize products made from rolled, pressed, and forged steel shapes, castings, plates, bars, and strips indicated to be galvanized shall comply with ASTM A123/A123M.

1. Hot-dip galvanized steel and iron hardware indicated to be galvanized shall comply with ASTM A153/A153M.

2. Do not quench or apply post-galvanizing treatments that might interfere with paint adhesion

B. Powder-Coat Finish: Prepare, treat, and coat non-galvanized ferrous metal to comply with resin manufacturer's written instructions and as follows:

1. Prepare uncoated ferrous-metal surfaces to comply with SSPC SP6/NACE No. 3.

2. Apply thermosetting polyester or acrylic urethane powder coating with cured-film thickness not less than 1.5 mils or resin manufacturer's recommended thickness, whichever is greater.

3. Color and Sheen: Black, satin.

C. Powder-Coat Finish: Prepare, treat, and coat galvanized metal to comply with resin manufacturer's written instructions and as follows:

1. Prepare galvanized metal by thoroughly removing grease, dirt, oil, flux, and other foreign matter.

2. Treat prepared metal with zinc-phosphate pretreatment, rinse, and seal surfaces.

3. Apply thermosetting polyester or acrylic urethan powder coating with cured-film thickness not less than 1.5 mils or resin manufacturer's recommended thickness, whichever is greater.

4. Color and Sheen: Black, satin.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Verify that substrates are stable and capable of supporting the weight of signage units.

B. Verify that substrates have been adequately prepared to securely anchor signage units.

C. Locate existing reinforcement in existing concrete to avoid conflicts with the proposed anchorages in the field.

3.02 PREPARATION

A. Clean surfaces thoroughly prior to installation.

B. Protect surrounding finishes and fixtures from damage by work of this Section.

3.03 INSTALLATION

A. Install signs and accessories where indicated, using mounting methods of types described and complying with manufacturer's written instructions and approved Shop Drawings.

B. Install signs level, plumb, and at heights indicated, with sign surfaces free of distortion and other defects in appearance.

C. Bracket-Mounted Signs: Provide brackets, fittings, and hardware for mounting signs that project from walls and are suspended from ceilings. Attach brackets and fittings securely to walls and ceilings with concealed fasteners and anchoring devices to comply with Contract Documents and approved Shop Drawings.

D. Connect exit signage lighting to emergency power circuit.

3.04 CLEANING AND PROTECTION

A. Clean exposed surfaces in accordance with manufacturer's instructions.

END OF SECTION 10 14 33

SECTION 10 21 14

METAL TOILET COMPARTMENTS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Toilet compartments.

B. Urinal screens.

1.02 MEASUREMENT AND PAYMENT

A. General: Metal toilet partitions and urinal screens will not be measured separately for payment but will be paid for as part of the Contract lump-sum price for Architectural Work.

1.03 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data and Samples, for submittal requirements and procedures.

B. Shop Drawings: Show compartment and urinal screen layouts, swing of doors, elevations, anchorage and installation details, components, hardware, accessories, finishes, and relevant dimensions.

C. Product Data: Submit manufacturer's product data of specified toilet compartments and urinal screens.

PART 2 – PRODUCTS

2.01 TOILET COMPARTMENTS

A. Compartment Type: Toilet compartments shall be manufactured from Type No. 304 stainless steel with No. 4 finish and shall be of the following types as indicated:

1. Floor Supported and Headrail Braced Units: Floor-anchored pilasters with pilasters connected and reinforced by headrail bracing, and wall-mounted partition panels.

2. Floor Supported Units: Floor-anchored pilasters and wall-mounted partition panels.

3. Ceiling Supported Units: Ceiling hung pilasters anchored to concealed, above-ceiling structural members, and wall-mounted partition panels.

B. Doors: Flush panel, one-inch thick, with two sheets of minimum 22 gage stainless steel sheet, bonded under pressure to both surfaces of manufacturer's standard core material. Formed edges shall be welded every 18 inches and sealed with a surrounding oval-crown, polished stainless steel locking strip that is mitered, welded and finished at the corners.

C. Panels: Flush panel, one-inch thick of same materials and construction as specified for doors, with insulating core material.

D. Pilasters: Flush panel, one and a fourth inch thick, with two sheets of minimum 18 gage stainless steel sheet, constructed welded, and finished as specified for doors.

E. Installation Accessories: Provide all fittings, fasteners, and installation hardware as required for a complete and finished installation. Anchorage and installation accessories shall be stainless steel and shall be concealed and made vandal-proof with the installation of stainless steel trim plates secured with theft-proof bolts. Stirrup brackets used to attach panels and pilasters shall be heat-treated, polished, clear anodized aluminum.

F. Hardware: Hardware shall consist of standard type gravity hinge which allows the door to remain open at any angle, heavy latch with combination keeper and rubber-faced strike, and coat hook with rubber bumper. Hardware shall be stainless steel or chrome-plated alloy as noted herein, manufactured or furnished by the manufacturer of the toilet partitions. Hardware shall include the following features and accessories:

1. Each door shall be equipped with chrome-plated, cast alloy coat hook and bumper, concealed latch with stainless steel bolt permitting exterior access, one-piece chrome-plated stop and keeper, and concealed controlled power bearing gravity hinge.

2. Door shall be adjustable to permit rest position at any angle within a 270-degree arc and the weight shall be carried by a thrust bearing with all moving parts concealed within door thickness.

3. Top hinge pin shall be secured at three points with stainless steel door hinge fittings fully flush with face plates of door.

4. Pilaster hinge brackets shall be of stainless steel alloy and factory mounted flush to pilaster.

5. Fasteners shall be stainless steel unless approved by District Representative.

2.02 **URINAL SCREENS**

A. Urinal screens shall be manufactured from Type 304 stainless steel of same materials and construction as herein specified for doors, and shall be furnished complete with all fittings, fastenings, and anchorage devices as required for a complete installation.

B. Urinal screens shall be flush panel, wall-mounted with brackets or floor-supported with pilasters as indicated. Urinal screens shall be 18 inches in width for wall-mounted screens and 24 inches in width for floor-supported screens.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Toilet compartments and urinal screens shall be installed as indicated by the manufacturer or its authorized representative in accordance with the manufacturer's installation instructions and recommendations. Install toilet compartments and urinal screens in a rigid and substantial manner, straight and plumb, with all horizontal lines level.

B. Pilaster anchors shall be carried through finish floor materials and secured to concrete structural slab for floor-supported units, and through finish ceiling materials and secured to above-ceiling structural supports for ceiling-supported units, as indicated, with shoes and adjustable anchors.

C. Drilling and cutting for installation of anchors shall be at locations that will be concealed in the finished work. Adjust pilaster shoes to fit flush against the floor and ceiling, as applicable. Clearance at walls shall be approximately one half inch. Clearance at vertical edges of doors shall be uniform from top to bottom and shall not exceed three sixteenth of an inch.

3.02 ADJUSTMENTS

A. Adjust and lubricate hardware for proper operation after installation and just prior to final inspection. Adjust door hardware so that doors are free of hinge bind.

B. Adjust hinges on in-swinging doors to hold doors open approximately 30 degrees from the closed position when unlatched. Adjust hinges on out-swinging doors to return doors to the fully open position (90 degrees) when doors are adjacent to walls, and to hold doors open approximately 15 degrees at intermediate locations.

3.03 COMPLETION

A. After completion of installation, remove protective maskings; clean and polish exposed surfaces of compartments and urinal screens, hardware, fittings, and accessories.

B. When complete, each compartment and urinal screen shall be square, plumb and level, accurately aligned, and securely anchored. Doors shall remain plumb in all positions of swing, and doors and hardware shall operate smoothly, quietly, and free from binding. Exposed surfaces shall be clean and free from scratches, dents, tool marks, stains, discoloration, and other defects and damage.

END OF SECTION 10 21 14

SECTION 10 21 15

PLASTIC TOILET COMPARTMENTS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Toilet compartments.

B. Urinal screens.

1.02 RELATED SECTIONS

A. Structural members for ceiling supported units are specified in Section 05 12 00, Structural Steel Framing, and Section 05 50 00, Metal Fabrications. Coordinate installation and anchorage requirements with the foregoing specified Division 5 Sections.

1.03 MEASUREMENT AND PAYMENT

A. General: Plastic toilet compartments will not be measured separately for payment but will be paid for as part of the Contract lump-sum price for Architectural Work.

1.04 SUBMITTALS

A. General: Refer to Contract Specifications Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Show compartment and urinal screen layouts, swing of doors, elevations, anchorage and installation details, components, hardware, accessories, finishes, and relevant dimensions.

C. Product Data: Submit manufacturer's product data of specified toilet compartments and urinal screens, including color charts for color selection.

PART 2 – PRODUCTS

2.01 TOILET COMPARTMENTS

A. Plastic Material: Partition panels, pilasters, and doors, and urinal screens shall be manufactured from high-density polymer resins which are waterproof, non-absorbent, and have a self-lubricating surface that resists markings from pens, pencils, and other writing instruments. Selected color shall extend uniformly throughout the body of the plastic panels.

B. Compartment Type: Toilet compartments shall be of the following types as indicated:

1. Floor Supported and Headrail Braced Units: Floor-anchored pilasters with pilasters connected and reinforced by headrail bracing, and wall-mounted partition panels.

2. Floor Supported Units: Floor-anchored pilasters and wall-mounted partition panels.

3. Ceiling Supported Units: Ceiling hung pilasters anchored to concealed, above-ceiling structural members, and wall-mounted partition panels.

C. Doors, Panels, and Pilasters: Flush panel, one-inch thick, solid homogeneous color as selected, with smooth rounded edges.

D. Installation Accessories: Provide all fittings, fasteners, and installation hardware as required for a complete and finished installation. Anchorage and installation accessories shall be 300 series stainless steel and shall be concealed and made vandal-proof with the installation of stainless steel trim plates secured with theft-proof bolts. Stirrup brackets used to attach panels and pilasters shall be heat-treated, polished, clear anodized aluminum.

E. Hardware: Hardware shall consist of standard type gravity hinge which allows the door to remain open at any angle, heavy latch with combination keeper and rubber-faced strike, and coat hook with rubber bumper. Hardware shall be stainless steel or chrome-plated alloy as noted herein, manufactured or furnished by the manufacturer of the toilet partitions. Hardware shall include the following features and accessories:

1. Each door shall be equipped with chrome-plated, cast alloy coat hook and bumper, concealed latch with stainless steel bolt permitting exterior access, one-piece chrome-plated stop and keeper, and concealed controlled power bearing gravity hinge.

2. Door shall be adjustable to permit rest position at any angle within a 270-degree arc, and the weight shall be carried by a thrust bearing with all moving parts concealed within door thickness.

3. Partition hardware, including hinge pins, shall be 300 series stainless steel. The hardware shall be specifically designed for use with polymer resins panels.

4. Fasteners shall be stainless steel, tamper-resistant.

2.02 URINAL SCREENS

A. Urinal screens shall be manufactured from polymer resins of same materials and construction as herein specified for partition panels, and shall be furnished complete with all fittings, fastenings, and anchorage devices as required for a complete installation.

B. Urinal screens shall be flush panel, wall-mounted with brackets or floor-supported with pilasters as indicated. Urinal screens shall be 18 inches in width for wall-mounted screens and 24 inches in width for floor-supported screens.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Toilet compartments and urinal screens shall be installed as indicated by the manufacturer or its authorized representative in accordance with the manufacturer's installation instructions and recommendations. Install toilet compartments and urinal screens in a rigid and substantial manner, straight and plumb, with all horizontal lines level.

B. Pilaster anchors shall be carried through finish floor materials and secured to concrete slab for floor-supported units, and through finish ceiling materials and secured to above-ceiling structural supports for ceiling-supported units, as indicated, with shoes and adjustable anchors. Anchors require specific approval by the Engineer before they may be used in post-tensioned slabs, beams, and girders.

C. Drilling and cutting for installation of anchors shall be at locations that will be concealed in the finished work. Adjust pilaster shoes to fit flush against the floor and ceiling, as applicable. Clearance at walls shall be approximately one half inch. Clearance at vertical edges of doors shall be uniform from top to bottom and shall not exceed three sixteenth of an inch.

3.02 ADJUSTMENTS

A. Adjust and lubricate hardware for proper operation after installation and just prior to final inspection. Adjust door hardware so that doors are free of hinge bind.

B. Adjust hinges on in-swinging doors to hold doors open approximately 30 degrees from the closed position when unlatched. Adjust hinges on out-swinging doors to return doors to the fully open position (90 degrees) when doors are adjacent to walls, and to hold doors open approximately 15 degrees at intermediate locations.

3.03 COMPLETION

A. After completion of installation, remove protective maskings; clean exposed surfaces of compartments and urinal screens, hardware, fittings, and accessories.

B. When complete, each compartment and urinal screen shall be square, plumb and level, accurately aligned, and securely anchored. Doors shall remain plumb in all positions of swing, and doors and hardware shall operate smoothly, quietly, and free from binding. Exposed surfaces shall be clean and free from scratches, dents, tool marks, stains, discoloration, and other defects and damage.

END OF SECTION 10 21 15

SECTION 10 22 13

WIRE MESH PARTITIONS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Wire mesh partitions and ceiling.

B. Doors.

1.02 MEASUREMENT AND PAYMENT

A. General: Wire mesh partitions and ceiling will not be measured separately for payment but will be paid for as part of the Contract lump-sum price for Architectural Work.

1.03 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit detailed Shop Drawings of the wire mesh partitions and ceiling, including installation details, door, hardware, and accessories.

C. Product Data: Submit manufacturer's product data and specifications of the specified wire mesh partitions.

D. Samples: Submit a 12-inch by 12-inch wire mesh panel constructed of specified frame members and wire mesh.

PART 2 – PRODUCTS

2.01 WIRE MESH PARTITIONS AND CEILING

A. Wire Mesh: Crimped, 10 gage steel wire woven into a one and a half-inch square-pattern mesh or diamond-pattern mesh, as indicated, securely clinched to frame members.

B. Frame Members: One and a half inch by three fourths inch cold-rolled steel channels with three sixteenths-inch bolt holes approximately 24 inches on center.

C. Horizontal Reinforcing Members: One and a half inch by three fourths inch by one eighth inch cold-rolled steel channel with wire woven through, or two one-inch by one half-inch channels bolted or riveted toe-to-toe through mesh, and secured to vertical members. Provide number of horizontal reinforcing members to suit panel height as recommended by partition manufacturer for the proposed usage.

D. Stiffening Bars: Provide flat bar stiffener posts between abutting panel frames. Size as recommended by partition manufacturer for partition height required. Increase size of stiffening bars, if required, to maintain partition rigidity.

E. Top Capping Bars: Three-inch by 4.1-pound channel secured to top framing channel with one fourth inch "U" bolts spaced not more than 28 inches on center.

F. Floor Shoes: Cast metal, sized to suit vertical framing and to provide approximately six inches of clear space between finished floor and bottom horizontal frame members. Furnish units with set screw for leveling adjustment.

2.02 DOORS

A. Provide hinged door or sliding door, as indicated, meeting the following requirements:

1. Hinged Door: Door frame of one and a fourth inch by three fourths inch by one eighth inch steel channel with one and a fourth inch by one eighth inch flat bar cover on three sides, and one and three eighths inch by three fourths inch by one eighth inch angle riveted to the lock side. Door shall have one and a half pair of butt hinges riveted to both door and hinge bar. Door shall have mortise-type cylinder lock operated by key outside with recessed knob inside.

2. Sliding Door: Door frame of one and a half inch by three fourths inch by one eighth inch channel with one and a half inch by one eighth inch flat bar cover plate on all sides, and one eighth inch-thick strike bar on lock side. Provide two four-wheel roller-bearing hangers, box track, and bottom guide channel, and mortise-type cylinder lock operated by key outside with recessed knob inside. Align bottom of door with bottom of adjacent panels.

3. Lock Cylinders: Cylinders for locks are specified in Contract Specifications Section 08 71 00, Door Hardware.

2.03 FABRICATION

A. Do not provide components less than sizes indicated. Provide larger size components when recommended by partition component manufacturer for the proposed usage.

B. Provide anchorage devices, hardware, and installation accessories as required for a complete installation.

C. Provide manufacturer's standard galvanized finish for wire mesh, framing, and doors.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Wire mesh partitions and ceiling shall be installed as indicated and in accordance with the approved Shop Drawings and the manufacturer's installation instructions and recommendations.

B. Erect partitions plumb, rigid, properly aligned, and securely anchored and fastened in place, complying with the manufacturer's recommendations for the proposed usage.

C. Provide additional field bracing as necessary for rigid, secure, and seismically braced installation. Provide additional clips and bracing as required.

3.02 ADJUST AND CLEAN

A. Adjust doors for smooth operation without binding.

B. Touch up damaged finish after completion of installation, using field-applied touch-up cold galvanizing compound to match color of galvanizing.

END OF SECTION 10 22 13

SECTION 10 28 24

TOILET AND JANITORIAL ACCESSORIES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Seat cover dispensers.

B. Sanitary napkin disposal.

C. Towel dispensers.

D. Toilet roll and tissue dispenser.

E. Stainless steel shelf and clothes rod.

1.02 RELATED SECTIONS

A. Backing plates, blocking, and reinforcement as required for the mounting of accessory items on or in partitions, walls, or shafts, framed with heavy gage steel members, are specified in Contract Specifications Section 05 40 00, Cold-Formed Metal Framing, as applicable.

B. Fire-Retardant treated wood blocking and backing, where appropriate and acceptable, are specified in Contract Specifications Section 06 10 00, Rough Carpentry.

C. Backing plates, blocking, and reinforcement as required for the mounting of accessory items on or in partitions, walls, or shafts, framed with light gage sheet metal members, are specified in Contract Specifications Section 09 22 00, Supports for Plaster and Gypsum Board, as applicable.

1.03 MEASUREMENT AND PAYMENT

A. General: Toilet and bath accessories will not be measured separately for payment but will be paid for as part of the Contract lump-sum price for Architectural Work.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM A153/A153M Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

2. ASTM A240/A240M Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications

3. ASTM A269/A269M Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service

4. ASTM C1002 Standard Specification for Steel Self-Piercing Tapping Screws for Application of Gypsum Panel Products or Metal Plaster Bases to Wood Studs or Steel Studs

1.05 SUBMITTALS

A. Refer to Contract Specifications Sections 01 33 00, Submittal Procedures, and 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Submit manufacturer's product data illustrating each accessory item at large scale. Include manufacturer's installation details.

C. Submit one sample of each different accessory item specified to be used in the Contract. Approved samples will be returned and may be used in the work.

1.06 DELIVERY, STORAGE AND HANDLING

A. Refer to Contract Specifications Section 01 60 00, Product Requirements, for general requirements for delivery, storage, and handling procedures.

B. Do not deliver accessories to the Jobsite until rooms in which they will be located are ready to receive them for immediate installation.

C. Pack accessory items individually in a manner to protect accessory item and its finish.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Stainless Steel Sheet: ASTM A240/A240M, commercial grade, 22 gage, satin finish.

B. Stainless Steel Tubing: ASTM A269/A269M, commercial grade, seamless, satin finish.

C. Adhesive: Epoxy type contact cement.

D. Anchors and Fasteners:

1. Provide concealed fasteners where possible. Concealed fasteners shall be 300-Series stainless steel or galvanized steel conforming with ASTM A153/A153M, as appropriate. Exposed fasteners shall be 300-Series stainless steel.

2. Provide self-drilling, self-tapping, corrosion-resistant steel screws, conforming with ASTM C1002, where accessories are to be anchored to concealed backing plates 16 gage or less in thickness.

3. Provide galvanized expansion type anchors with matching galvanized screws, bolts, or studs where accessories are to be anchored to concrete or masonry. Provide galvanized steel washers under all screw heads, bolt heads, and nuts.

E. Janitor Shelving: ASTM A240/A240M, Type 304, composite stainless steel panel, free of buckles, waves, and surface imperfections, satin finish. Size as indicated.

F. Locks shall be tumbler type. All keyed accessories shall be keyed to conform to "CAT74" keying, except coin boxes of vending equipment.

2.02 FABRICATION

A. Weld and grind smooth joints of fabricated components. Welded joints shall be invisible in the finished work.

B. Form exposed surfaces from one sheet of stock, free of joints.

C. Form surfaces flat without distortion. Maintain flat surfaces without scratches or dents. Shelf edges shall be returned and hemmed. There shall be no sharp edges in the finished work.

D. Shop assemble components and package complete with anchors and fittings.

2.03 ACCESSORIES

A. General: Regarding accessories designated as District Designated Matching Products (DMP), refer to Contract Documents for product name brand and model number.

B. Janitorial Shelf: 12 inches wide, 16 gage, Type 304 stainless steel, satin finish, with 3/4 inch or one inch returned edge, hemmed. Length of shelf shall be as indicated. Provide painted steel support brackets as required.

C. Clothes Rod: Nominal one and a fourth inch diameter, heavy-duty stainless steel tube or pipe, Type 304, satin finish. Provide complete with stainless steel mounting flanges.

D. Seat cover dispensers – public: DMP. Wall-mounted behind and above toilet. Unit is recessed and keyed.

E. Seat cover dispensers – staff: DMP. Same as public except where recessing the unit is not possible, use surface-mounted, keyless; this exception shall apply to staff rooms only.

F. Sanitary napkin disposal – public: DMP. Wall-mounted behind and above toilet. Unit is recessed and keyed.

G. Sanitary napkin disposal – staff: DMP. Same as public except where recessing the unit is not possible, use surface-mounted, keyless; this exception shall apply to staff rooms only.

H. Towel dispensers – staff only toilets: DMP. Unit is surface-mounted and keyed. Where combination towel and waste receptacle is indicated, use recessed unit, keyed.

I. Toilet roll and tissue dispensers – public: Recessed, District furnished.

J. Toilet roll and tissue dispensers – staff: DMP. Double roll, keyed.

K. Soap dispensers – public: DMP. Wall-mounted above lavatory, recessed, vandal resistant with pump.

L. Soap dispensers – staff: DMP. Same as public except where recessing the unit is not possible, use surface-mounted; this exception shall apply to staff rooms only.

M. Mirrors – staff only: DMP. Framed glass mirror, 18 inches by 30 inches.

N. Hand dryer – public and staff: DMP. 120V, wall-mounted unit. Projection from wall: 8 inches maximum. Sensor-operated, white or brushed stainless steel to match other fixtures.

O. Robe Hook: Single robe hook, stainless steel with satin finish, projects 1 and 5/8 inch minimum, concealed fasteners.

PART 3 – EXECUTION

3.01 PREPARATION

A. Deliver inserts, backing plate mounting kits, and rough-in-frames to Jobsite at appropriate time for incorporating all such items into the construction. Provide templates and rough-in measurements as required.

B. Before starting work, correct any conditions detrimental to installation or operation of units.

3.02 INSTALLATION

A. Locate accessories as indicated. Provide one soap dispenser per lavatory. Provide one mop holder for each Janitor's Room service sink. Provide a minimum of one robe hook at disabled accessible height and one robe hook at conventional height at each single person toilet room.

B. Install fixtures, accessories, and items in accordance with the manufacturer's installation instructions and recommendations. Use security type fasteners.

C. Install true, plumb, and level, securely and rigidly anchored to backing plates, blocking, and reinforcement in the substrate construction.

D. Soap dispensers shall be located directly over lavatories in such a manner that the nozzle discharge shall fall into the lavatory bowl.

3.03 SCHEDULE OF TOILET ACCESSORIES

A. Refer to the Contract Specifications and Drawings for scheduled toilet and bath accessories.

END OF SECTION 10 28 24

SECTION 10 40 00

SAFETY SPECIALTIES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Fire extinguishers.

B. Fire extinguisher cabinets.

1.02 RELATED SECTIONS

A. Section 01 33 00, Submittal Procedures.

B. Section 01 33 23, Shop Drawings, Product Data, and Samples.

C. Section 05 70 00, Decorative Metal.

D. Section 21 12 00, Fire-Suppression Standpipe.

1.03 MEASUREMENT AND PAYMENT

A. General: Separate measurement or payment will not be made for the work required under this Section. All costs in connection with the Work specified herein will be considered to be included or incidental to the Work of this Contract.

1.04 REFERENCES

A. California Code of Regulations (CCR):

1. Title 24, California Fire Code, Portable Fire Extinguishers

B. National Fire Protection Association (NFPA):

1. NFPA 10 Portable Fire Extinguishers

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data and Samples, for submittal requirements and procedures.

B. Shop Drawings and Product Data: Submit Shop Drawings of installation details and manufacturer's product data for fire extinguishers, extinguisher cabinets, and installation accessories.

PART 2 – PRODUCTS

2.01 FIRE EXTINGUISHERS

A. Multi-Purpose Dry Chemical Extinguishers: Provide nominal five-pound or twenty-pound capacity extinguishers as indicated, rated as follows, unless otherwise noted:

1. Five Pounds: UL Rating of 3A-10B:C. For station agent's booth.

2. Twenty Pounds: UL Rating of 20A-120B:C. All other locations, except where carbon dioxide extinguishers are required.

B. Carbon Dioxide Extinguishers: Provide nominal 20-pound capacity extinguishers as indicated, rated as follows:

1. Twenty Pounds: UL Rating of 10-B:C. One for each electrical room and train control and communications room.

C. Mounting Brackets: When extinguishers are indicated to be wall mounted without cabinets, provide manufacturer's mounting brackets for sturdy, top and bottom support, properly sized for type and size of extinguisher, and to resist lateral forces from a design seismic event.

2.02 FIRE EXTINGUISHER CABINETS

A. Cabinets: Extinguisher cabinets shall be fully recessed type with flat trim or semi-recessed type with rolled edge as indicated, comply with Section 05 70 00, Decorative Metal. Cabinets at parking structures may be surface mounted with rolled edges and radiused corners. Cabinets shall be of size required for size of extinguisher, fabricated from Type 316 stainless steel with ASTM A480 or NAAMM APM 503, No. 4 finish, with solid stainless steel door. Provide fire-rated cabinets where recessed in fire-rated walls.

1. Door shall be lockable. Furnished with flush type stainless steel door pull, with spring loaded catch activated by a pull device. Latch shall be replaceable and vandal resistant.

2. Joints in cabinets shall be made watertight, and doors shall be gasketed to minimize moisture intrusion. Provide weep holes in bottom of cabinet.

B. Cabinet Identification

1. Cabinets shall be labeled with the words "FIRE EXTINGUISHER" in one inch high letters, Univers 65.

2. Letters shall be black in color for stations and red in color for parking structure, as selected by the Engineer. The letters shall be provided for all cabinets; standard applied die cut letters, capital letters.

PART 3 – EXECUTION

3.01 INSPECTION

A. Verify that space in fire hose cabinets is sufficient to receive indicated fire extinguishers.

3.02 INSTALLATION

A. Install fire extinguishers and extinguisher cabinets plumb and level as indicated. Install securely in place in accordance with the manufacturer's installation instructions and in compliance with applicable requirements of the California Fire Code and NFPA 10.

END OF SECTION 10 40 00

SECTION 10 51 19

METAL LOCKERS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Metal lockers.

B. Locker benches.

1.02 MEASUREMENT AND PAYMENT

A. General: Metal lockers and benches will not be measured separately for payment but will be paid for as part of the Contract lump-sum price for Architectural Work.

1.03 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data and Samples, for submittal requirements and procedures.

B. Shop Drawings and Product Data: Submit fully detailed Shop Drawings and manufacturer's product data of metal lockers and benches, including layout of lockers, color chips, and installation details. Include pedestal anchorage details for benches.

C. Samples: Submit locker manufacturer's standard color samples for selection. Submit six inches by nine and a half inches (full width) by one and a fourth inch samples of finished bench top.

PART 2 – PRODUCTS

2.01 LOCKERS

A. Type and Manufacture: Lockers shall be Standard Single Tier or Double Tier and Accessible Single Tier or Double Lockers of width, depth, and height as indicated. Lockers shall be furnished with sloping tops, raised bases, fillers as needed, panel ends, anchors, fasteners, and accessories as required for a complete and finished installation. Lockers shall be manufactured to meet or exceed the following requirements:

1. Locker Units: Size and configuration as indicated.

2. Bodies: Minimum 24 gage sheet steel, formed and flanged with stiffener ribs; electrically spot welded. Bolt spacing shall not exceed nine inches on center.

a. Do not install mounting fasteners through the bottom of the lower locker unless it is within one and a half inches of the hinge side or the back of the locker.

3. Door Frame: Minimum 16 gage sheet steel, formed channel shape, welded and ground flush, welded to locker body.

4. Doors: Minimum 18 gage sheet steel, formed channel shape at vertical edges, flanged at top and bottom, with louvers at top and bottom of door face.

5. Locker Top, Closure Panels, and Trim: Provide end panels and filler panels to close off all openings. Provide continuous sloping top. Top, panels, and trim shall be minimum 20 gage sheet steel. Finish edges smooth without burrs.

B. Hardware:

1. Door Handle: Door handle and latching mechanism shall be the manufacturer's accessible lever handle with integral feature for locking the door with a padlock, manufactured from a chrome-plated non-corrosive alloy.

2. Hinges: Provide two hinges for doors under 42 inches in height and three hinges for doors over 42 inches in height. Weld hinges securely to locker frame and rivet securely to the door.

C. Number Plates: Polished aluminum or stainless steel with a half inch high black figures. Numbering shall be provided, beginning with the number 100 and numbered consecutively thereafter.

D. Finish: Lockers, all exposed parts exterior and interior, panels, and enclosures, shall be bonderized or phosphatized to assure maximum paint adherence, primed with a corrosion-inhibitive metal primer, and finished with manufacturer's baked enamel in color as selected by the Engineer from manufacturer's standards.

2.02 LOCKER BENCHES

A. Benches shall be manufactured from laminated maple mounted on steel tube pedestals, as follows:

1. Pedestals and Anchors: Pedestals shall consist of one and a half inch nominal diameter steel tube with 10 gage steel flanges welded to each end. Welds shall be ground and dressed smooth. Provide anchorage with a half inch diameter galvanized steel expansion type anchor bolts as specified in Section 05 50 00, Metal Fabrications. Provide finish for pedestals as herein specified for lockers.

2. Bench Tops: Laminated maple, one and fourth inches in full finished thickness by nine and a half inches wide. Provide bench tops with clear penetrating lacquer or polyurethane finish, satin in texture.

3. Overall Bench Height: 18 inches nominal.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Lockers and benches shall be installed as indicated and in accordance with the approved Shop Drawings and the manufacturer's installation instructions and recommendations. Install lockers and benches in a rigid and substantial manner, straight and plumb, with all horizontal lines level.

B. Anchor lockers with appropriate anchor devices to suit materials encountered. Bolt adjoining locker units together to provide rigid installation. Install sloping top, end panels, and filler panels to completely close off openings.

1. Bolts in bottom of locker shall be within two inches of the back or hinged side walls.

C. Adjust and lubricate hardware for proper operation after installation. Doors shall be free from hinge bind after installation.

D. Clean lockers and benches on completion of work and leave free from imperfections. Protect from damage until Contract acceptance.

E. Lockers shall be secured to the wall to resist lateral forces from a seismic event. Fastenings shall be designed by the Contractor to resist calculated loads of full lockers.

END OF SECTION 10 51 19

SECTION 10 81 13

BIRD CONTROL DEVICES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Wire mesh barriers.

B. Bird wire systems.

C. Bird spike strips.

D. Bird spiders.

E. Bird slopes.

1.02 RELATED SECTIONS

A. Section 01 33 00, Submittal Procedures

B. Section 01 33 23, Shop Drawings, Product Data, and Samples

C. Section 01 43 00, Quality Assurance

D. Section 01 74 14, Cleaning

E. Section 07 60 00, Flashing and Sheet Metal

F. Section 10 22 13, Wire Mesh Partitions

1.03 MEASUREMENT AND PAYMENT

A. General: Bird Control Devices will not be measured separately for payment but will be paid for as part of the Contract lump sum price for Architectural Work.

1.04 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit detailed Shop Drawings of the bird control devices including installation, hardware, and accessories.

C. Product Data:

1. Manufacturer’s product data and installation instructions.

2. Catalog cuts, marked to indicate applicable requirements.

D. Samples: Submit one sample for each product used. Refer to 01 33 23, Shop Drawings, Product Data, and Samples for other sample requirements.

1. Bird control strips: minimum 6 inch sample.

2. Bird wire system: one base with posts and attached wire.

3. Wire mesh barrier: minimum 6 inch square sample.

4. Bird spider: one assembly.

5. Bird slope: 6 inch section.

1.05 QUALITY ASSURANCE

A. Refer to Contract Specifications Section 01 43 00, Quality Assurance.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver products in original unopened packaging with legible manufacturer's identification.

B. Store delivered products in clean, safe, dry area.

1.07 PROJECT CONDITIONS

A. Coordination: Coordinate installation with other work, existing conditions, and within on-site tolerances. Provide hardware and accessories as necessary for the proper installation and function.

B. Visit site and field measure prior to fabrication and delivery of materials.

1.08 WARRANTY

A. Provide manufacturer's guarantee as follows:

1. Bird wire system: Five years

2. Bird spike strips: Five years

PART 2 – PRODUCTS

2.01 WIRE MESH BARRIERS

A. Material: 1 inch square mesh, 12 gauge welded wire mesh with PVC coating.

B. Color: as selected by the Engineer.

C. Hardware: as recommended by manufacturer.

2.02 BIRD WIRE SYSTEM

A. Materials: stainless steel #316 wire with spring connections to posts in continuous parallel rows at 3 inch on center for full length of surface.

B. Posts: stainless steel single eye. Connection shall be as indicated on Contract Drawings.

2.03 BIRD SPIKE STRIPS

A. Material: Ultraviolet (UV) stabilized polycarbonate or stainless steel, heat and weather resistant form -200 to +300 degrees Fahrenheit, one piece construction, minimum 3 inch width, minimum 4 inch height, minimum 40 spikes per foot in linear array with no gap center spike, non-staggered design, and flexible for wrapping around rounded surface (e.g. light fixture).

B. Mounting: adhesive as recommended by manufacturer.

C. Color: as selected by the Engineer.

2.04 BIRD SPIDER

A. Material: stainless steel arms attached to a UV protected polycarbonate base. Each arm shall be fitted with polycarbonate tip to assist in movement and prevent scuffing.

B. Size: as selected by the Engineer.

C. Mounting: adhesive as recommended by manufacturer.

2.05 BIRD SLOPE

A. Material: Powder-coated sheet metal 60 degree slope. Bent cap projections and ledges. Thickness indicated in Contract Drawings. Refer to Contract Specifications 07 60 00, Flashing and Sheet Metal.

B. Color: as selected by the Engineer.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Examine the area and delivered products and verify that:

1. Dimensions are correct to the delivered products.

2. Adjacent or adjoining surfaces are clean, dry, reasonably smooth, and free from defects.

3. There is absence of other conditions that will adversely affect installation.

B. Do not start work until unsatisfactory conditions have been corrected.

3.02 SURFACE PREPARATION

A. Prior to installation, clear surface of bird dropping, nesting material or other debris in accordance to Section 01 74 14, Cleaning. Remove or repair articles that may damage after installation, including overhanging foliage, brush, and loose parts of the structure. Use appropriate disinfectant to prepare surface.

3.03 INSTALLATION

A. Install bird control devices in accordance with manufacturer's recommendation and reviewed Shop Drawings.

B. Bird Control Strip: Install bird control where noted, leaving no gaps for perching.

C. Bird Spider: Install bird spider with adhesive to the surface in accordance with manufacturer's instructions.

D. Bird Wire

1. Install bird wire control system where indicated on the Contract Drawings, leaving no gaps for perching.

2. Number of rows as determined by manufacturer and based on project conditions.

3. Install wire taut.

E. Wire Mesh Barriers: Install in accordance to Contract Specifications 10 22 13, Wire Mesh Partitions.

F. Bird Slope: Install in accordance to Contract Specifications 07 60 00, Flashing and Sheet Metal.

3.04 PROTECTION

A. Protect work from damage to surface, profile and shape.

END OF SECTION 10 81 13

SECTION 11 31 00

RESIDENTIAL APPLIANCES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Refrigerators.

B. Microwave ovens.

1.02 RELATED SECTIONS

A. Section 01 33 00, Submittal Procedures.

B. Section 01 33 23, Shop Drawings, Product Data, and Samples.

C. Section 01 78 23, Operation and Maintenance Data.

D. Section 01 81 13, Sustainability Requirements.

1.03 MEASUREMENT AND PAYMENT

A. General: Separate measurement or payment will not be made for the work required under this Section. All costs in connection with the Work specified herein will be considered to be included or incidental to the Work of this Contract.

1.04 REFERENCES

A. U.S. Environmental Protection Agency (EPA) and U.S. Department of Energy (DOE) Energy Star program

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data and Samples, for submittal requirements and procedures.

B. Product Data: Submit description of appliances, including materials, finishes, and energy consumption.

C. O&M Instructions: Submit manufacturer's operation and maintenance instructions in accordance with the requirements of Section 01 78 23, Operation and Maintenance Data, for off-the-shelf manuals.

PART 2 – PRODUCTS

2.01 RESIDENTIAL APPLIANCES

A. Type and Manufacture: Provide standard manufactured appliances as indicated. Appliances shall be white.

B. Microwave Oven: Provide a countertop microwave oven, 1.5 cubic foot capacity. Electrical requirements: 120VAC, 1.2 kW, 10 A. Minimum 1100 watts. Maximum width 23 inches. Microwave oven shall be a plug-in type appliance and approved by a nationally known testing laboratory.

C. Conventional Refrigerator with Freezer: Provide 18.2 cubic feet top freezer refrigerator, frost-free, with lighting at fresh food compartment and interior up-front controls. Refrigerator shall qualify for EPA/DOE Energy Star product labeling program. Freezer capacity shall be minimum four cubic feet and fresh food capacity shall be minimum 14 cubic feet. Provide with two ice cube trays. Refrigerator shall be plug-in type. Electrical requirements, 115VAC, two wire, 60 Hz, and shall be approved by a nationally known testing laboratory.

D. Removable Undercounter Refrigerator: Refrigerator shall have a minimum capacity of 5.8 cubic feet. In the fresh food compartment the refrigerator shall have three full-width shelves, three shelves on the door, and light. Provide with two ice cube trays. The temperature control shall be mounted in the interior of the refrigerator cabinet. Defrost control: Automatic. Refrigerator shall be plug-in type, 115VAC, two-wire, 60 Hz, and shall be listed or approved by a nationally known testing laboratory. Refrigerator shall be selected to fit under countertop as indicated and Energy Star Certified.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install appliances as indicated and in accordance with the manufacturer’s installation instructions and recommendations.

B. In addition to complying with O&M manual submittal requirements specified herein, include one copy of each appliance’s standard owner’s manual in the cabinetry adjacent to the appliances for convenient of users. Enclose manuals in heavy duty plastic bag, such as zip-loc freezer bag.

END OF SECTION 11 31 00

SECTION 14 21 00

ELECTRIC TRACTION ELEVATORS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Hoistway Construction.

B. Machine Room.

C. Equipment in Hoistway and Machine Room.

D. Hoistway Entrances.

E. Car and Hoistway Doors.

F. Electronic Door Edge Sensor.

G. Car Enclosure.

H. Elevator Floor and Platform.

I. Electrical Components.

J. Controller.

K. Remote Monitoring System.

L. Signals and Operating Fixtures.

M. Recessed Motion Sensing Unit.

N. Cameras.

O. Signs.

P. Vibration Absorption Mounts.

1.02 RELATED SECTIONS

A. Section 03 61 11, Non-Shrink Grout

B. Section 08 90 00, Louvers

C. Section 09 91 00, Painting

D. Section 09 67 70, Elevator Spray-On Flooring

E. Section 10 40 00, Safety Specialties

F. Section 20 70 26, Common Materials and Methods for Electrical Systems

G. Section 26 05 24, Low and Medium Voltage Wires and Cables

H. Section 26 50 00, Lighting

I. Section 27 30 01, Telephone Systems

J. Section 28 31 00, Fire Detection and Alarm System

K. Section 28 41 29, Closed Circuit Television Systems

1.03 MEASUREMENT AND PAYMENT

A. General: The elevator will not be measured separately for payment but will be paid for as part of the indicated Contract lump sum price for elevator.

1. Elevator maintenance will be paid as lump sum price as indicated on the Bid Form.

2. Chargeable repairs will be paid separately for labor and maintenance as indicated on the Bid Form. Labor will be paid as unit price and material will be actual cost plus mark-up as indicated on the Bid Form.

1.04 REFERENCES:

The requirements of the prevailing versions of the following standards at time of contract signing shall be met.

A. American National Standards Institute (ANSI):

1. ANSI A117.1 Accessible and Usable Buildings and Facilities

2. ANSI Z97.1 Glazing Materials Used in Buildings, Safety Performance Specifications and Methods of Test

B. American Society of Mechanical Engineers (ASME):

1. ASME A17.1 Safety Code for Elevators and Escalators

2. ASME A17.2 Guide for Inspection of Elevators, Escalators, and Moving Walks

3. ASME A17.3 Safety Code for Existing Elevators and Escalators includes Requirements for Electric and Hydraulic Elevators and Escalators

C. American Society for Testing and Materials (ASTM):

1. ASTM A36/ A36M Specification for Carbon Structural Steel

2. ASTM A1008/ A1008M — Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable
3. ASTM B3 — Specification for Soft or Annealed Copper Wire
4. ASTM B174 — Specification for Bunch-Stranded Copper Conductors for Electrical Conductors
5. ASTM B209 — Specification for Aluminum and Aluminum-Alloy Sheet and Plate
6. ASTM B211 — Specification for Aluminum and Aluminum-Alloy Rolled or Cold Finished Bar, Rod, and Wire
7. ASTM B221 — Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
8. ASTM B308/ B303M — Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles
9. ASTM C864 — Specification for Dense Elastomeric Compression Seal Gaskets, Setting Blocks, and Spacers
10. ASTM C1048 — Specification for Heat-Strengthened and Fully Tempered Flat Glass
11. ASTM D2240 — Test Method for Rubber Property-Durometer Hardness
12. ASTM F36 — Test Method for Compressibility and Recovery of Gasket Materials

D. American Welding Society (AWS):

1. AWS D1.1 — Structural Welding Code - Steel

E. National Association of Architectural Metal Manufacturers (NAAMM):

1. AMP 503 — Finishes for Stainless Steel

National Electrical Manufacturers Association (NEMA):

1. NEMA AB 1 — Molded-Case Circuit Breakers, Molded Case Switches, and Circuit-Breaker Enclosures
2. NEMA PB 1 — Panelboards

F. National Elevator Industry, Inc. (NEII):

1. NEII-1 — Building Transportation Standards and Guidelines

G. National Fire Protection Association (NFPA):

1. NFPA 70 National Electrical Code
2. NFPA 101 Life Safety Code

H. Steel Structures Painting Council (SSPC):

1. SSPC-SP 1 Solvent Cleaning
2. SSPC-SP 3 Power Tool Cleaning
3. SSPC-CS23.00 Specification for the Application of Thermal Spray Coating (Metallizing) of Aluminum, Zinc, and Their Alloys and Composites for the Corrosion Protection of Steel

I. Underwriters Laboratories Inc. (UL):

1. UL 62 Flexible Cords and Cables
2. UL 1581 Reference Standard for Electrical Wires, Cables, And Flexible Cords

J. District Technical Manual – SCADA System Function Description

K. BART Facilities Standard Drawings AS08, AS09, AS10, AS11, Architectural Elevator Details

1.05 REGULATORY REQUIREMENTS

A. In addition to the foregoing referenced standards, any regulatory requirements which govern elevator work of these Specifications shall include at a minimum the following codes and regulations:

B. Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities (ADAAG Guidelines) 49 CFR Subtitle A, Part 37, Appendix A.

C. California Code of Regulations (CCR):

1. CCR Title 8, Industrial Relations
2. CCR Title 24, Part 2, California Building Code (CBC)
3. CCR Title 24, Part 3, California Electrical Code

D. California Occupational Safety and Health Act (CAL/OSHA)

E. In the event of a conflict between codes, regulations, standards or these specifications, the most stringent requirement shall take precedence unless specifically required by the Engineer.

1.06 QUALITY ASSURANCE

A. The Contractor shall be responsible for integrating all elevator and hositway components and related systems to ensure a fully compliant, operable system.

B. General: At the completion of the work, the elevator shall meet the minimum requirements of CCR Title 8, CCR Title 24, Part 2, NEC, ASME A17.1, A17.2, A17.3, and NFPA 101. Install per manufacturer's requirements and as specified herein.

C. Comply with AWS D1.1 standards for finished work and for qualifications of welding operators and corrosion protection.

D. The controller wiring shall be carried out in accordance with the minimum requirements of CCR, Title 24, Part 3, California Electrical Code.

1.07 SYSTEM DESCRIPTION

A. Elevator Type: Geared traction with AC drive motor, 480 V, 3 phase

B. Load Capacity: 3,500 pounds for elevators with side opening doors and 4,000 pounds for elevators with center opening doors in all stations and parking structures.

C. Speed: 100 feet per minute for Station Elevators and 250 feet per minute for Parking Structure Elevators, or as determined by the Engineer with maximum 5 percent speed variation under any loading condition in either direction.

D. Stops: As indicated.

E. Main Floor: Ground floor, unless otherwise specified in the Contract Specifications.

F. Entrance size:

1. Minimum 42 inches wide by 84 inches high for elevators with side opening doors.

2. Minimum 48 inches wide by 84 inches high for elevators with center opening doors.

3. Entrances shall be sized for emergency evacuation of a horizontally positioned ambulance stretcher 24 inches by 84 inches or per fire department having jurisdiction, whichever is greater.

G. Travel: As indicated and verified in field.

H. Controller: The controller shall be a Designated Matching Product (DMP) as specified herein.

I. Machine Location: Overhead, typical.

J. Car Inside Dimension: Car minimum inside clear dimension shall be 80 inches wide by 63 inches deep for Passenger Station Elevators and 82 inches wide by 72 inches deep for Parking Structure Elevators from wall to wall. Height from floor to ceiling shall be 96 inches minimum.

K. Remote Monitoring System: The elevator Remote Monitoring System (RMS) shall be interface with the existing BART Escalator/Elevator monitoring system (EERMS), as specified herein.

L. Electronic car door edge sensors: Sensors shall be a District Matching Product (DMP) as specified herein.

M. Car Enclosure: Passenger type.

N. Comply with standards established in the NEII Building Transportation Standards and Guidelines, unless specified otherwise herein.

O. Doors:

1. For elevators rated for 3,500 pounds, car and hoistway doors shall be side opening.

2. For elevators rated for 4,000 pounds, car and hoistway doors shall be center opening.

3. Car and hoistway doors shall be horizontal, sliding, single speed, stainless steel with a vision panel in each door.

1.08 DESIGN AND OPERATION REQUIREMENTS

A. Elevator System General Requirements:

1. Elevators shall be designed specifically for the operation, loading and environmental conditions encountered in extensively used, heavy duty rail transit systems and shall have a minimum design life of 20 years.

2. Elevators shall operate while exposed to sunlight, rain, airborne dust, and debris.

3. The final assembly of all components shall not pose hazardous conditions to the public or maintenance personnel. Surface irregularities, sharp edges, or protrusions in public or maintenance areas shall not be permitted.

4. Provide convenient and safe equipment access for inspection, cleaning, maintenance, repair, and replacement.

5. All gaps and running openings within regulatory tolerances shall be properly closed by the use of appropriate sealant or another approved means installed in accordance with the manufacturers' instructions.

6. For parts and equipment subject to wear and requiring periodic replacement, the Contractor shall furnish key and seat, nut, screws, or other removable and replaceable type mechanical fasteners. Such replacements shall not diminish original structural integrity. Use of rivets or similar type fasteners requiring physical deformation during field positioning will not be permitted.

7. The elevator equipment shall be quiet and smooth running and shall not exceed the following maximum noise output levels during all phases of operation:

    a. Eighty decibels measured in the elevator machine room

    b. Seventy decibels measured in the elevator car

    c. Seventy decibels measured at the elevator hoistway entrances

8. Fire Protection: Contractor shall provide non-combustible materials for components.

B. Seismic Criteria:

1. Installation and equipment designed for static and for seismic conditions shall be provided in accordance with regulatory requirements.

2. Provide hardware necessary to protect motors, drives, and door operators.

3. Seismic design shall be based on seismic requirements for elevators in ASME A17.1 and section 3137 (a) of The California Code of Regulations in effect at the time of Contract signing.

C. Power:

1. The main elevator power shall be 480 Vac, three phase, 60 Hertz.

2. As a minimum, three separate 120 Volt circuits shall be provided for each of the following: elevator car lighting, elevator pit and hoistway lighting and receptacles, and car camera. Any 120 Volt elevator control circuits shall be provided from the elevator controller by means of a step down transformer.

D. Elevator Controller:

1. Refer to Article 2.13, Controller, herein. The controller for Station Elevators shall be a field programmable microprocessor based, simplex selective-collective, automatic operation with closed loop, variable voltage, variable frequency control. The controller for Parking Structure Elevators shall be a field programmable microprocessor based, group automatic operation with closed loop.

2. Elevator operation shall be by means of pushbuttons in the car, at terminal and intermediate landings numbered to correspond to landings served, by SINGLE CALL pushbuttons at terminal landings, and by UP and DOWN pushbuttons at intermediate landings.

3. The activation of one or more pushbuttons shall illuminate the pushbuttons and dispatch the nearest car to the designated landings in the order in which the landings are reached by the car, regardless of the order in which the calls were registered. When the car reaches the landing, the illumination of the corresponding pushbutton shall cease.

4. If hall calls are received for the opposite direction of travel, the car shall continue in the same direction until all calls in the initial direction are answered, then the car shall reverse direction to collect call in the opposite direction.

5. If no calls are registered and the car is unoccupied, the car shall either remain at that landing until further calls are registered or be dispatched to the designated, programable, home landing and stop without door operation.

6. Special Operations:

    a. Inspection Operation: Inside the car service cabinet within the Car Operating Panel, there shall be an Inspection key-operated switch for normal “run” or “inspection” operation. There shall be three means of car movement for inspection operation; at the car top inspection station, inside the controller, and by the hoistway access key switches. Car movements initiated by the car-top inspection station or by the hoistway key switches shall be at low or full speed and disable the controller inspection switch. The controller shall be equipped with a toggle switch for low or high speed selection. The car will run either up or down by constant pressure on the up or down switches, provided the doors are closed and the safety circuit is made. Releasing the directional button will cause the car to stop immediately. Activating any of the run/stop switches to “stop” position will render the car inoperative. Turning the inspection switch to the “run” position will restore the car to automatic operation.

    b. Independent Service: A key switch shall be provided in the car service cabinet to allow for independent service. The car can be removed from automatic operation and be operated manually. Independent service shall have full control of the starting, stopping, and direction of car travel. The car shall respond to car buttons only. The arrival gongs, hall lanterns, and hall calls shall be inoperative during independent service mode.

    c. Operation Under Fire Conditions: Provide special fire service to comply with the requirements of CCR Title 24, Part 2, California Building Code, Chapter 30 for State Fire Marshal (SFM) facilities, ASME A17.1, and local fire codes having jurisdiction. As a minimum, provide the following:

        1) Phase I recall, three-position key switch at main (egress floor) level keyed to EX 515 shall be integrated in hall call stations with engraved instructions. Elevator operation shall be in accordance with the applicable codes.

        2) Phase II fire service shall be provided. A three position key-operated switch keyed to EX 515 shall be mounted in the Car Operating Panel and operate in accordance with applicable codes.

3) All initiating fire alarm signals shall be routed to the main fire alarm panel through four fire alarm control relays with the following signals:

   a) Primary Recall.

   b) Secondary Recall.

   c) Shunt Trip.

   d) Fire Fighter's Hat.

   The relays shall be installed inside a red NEMA 4 box within 3 feet of the elevator controller. The station fire alarm panel shall initiate the appropriate signals to the elevator controller in accordance with applicable codes.

4) Spot-type photoelectric smoke or heat detectors (depending upon the hazard's environment) will be provided adjacent to the station and parking structure elevator openings (located in accordance with the relevant requirements within the code). With the exception of the detector located adjacent to the elevator opening on the primary elevator recall floor, operation of any of these detectors will initiate the elevator capture and recall functions from the FACU to recall the elevator to the designated primary floor. Operation of the detector adjacent to the elevator opening on the primary recall floor will initiate the elevator capture and recall functions from the FACU to recall the elevator to the designated secondary floor. These devices will communicate with, and be powered from the FACU. Operation of a device will cause an alarm signal to be transmitted to the FACU; will cause operation of all of the station's occupant notification appliances; will cause transmission of an alarm signal to BART's monitoring location; and will cause the recall operations identified above.

d. Operation under Earthquake Conditions: Provide seismic operation in accordance with the requirements of CCR Title 8. Provide a counterweight derailment device (ring and string). Each location shall be equipped with a seismic device in the Train Control Room, Auxiliary Communications Room, or elevator equipment room as indicated on the Contract Drawings that provides a set of dry contacts for the control of the elevators and escalators within that station or parking structure. If a seismic device is indicated in the Parking Structure elevator equipment room, that device shall also be equipped with a set of contacts to the communications room as indicated on the Contract Drawings. Provide the wiring, raceway and elevator controller circuitry for the seismic control circuit or circuits.

e. Operation under Standby Power: Provide standby power to each elevator from the permanent emergency generator system. A control signal from the generator shall be provided to the elevator controller or elevator group to place the elevator or group of elevators in emergency power mode, which will cause the elevators to return to the designated floor and remain there with the doors open. If there are a group of elevators, power shall be provided to only one elevator at a time and automatically switch to the remaining elevators until all elevators have returned to the designated floor with the

doors open. Provide an EX 513 key operated selector fixture, for stand-by power operation. Design and location to be approved by the Engineer.

7. The controller shall be equipped to provide remote control and indication signals to the Station Agents Booth as specified in Article 2.15, Signals and Operating Fixtures.

    a. Car moving up (indication) for Station Elevators only.

    b. Car moving down (indication) for Station Elevators only.

    c. Concourse (control & indication, car call) for Station Elevators only.

    d. Street or Platform, one for each landing as required (control and indication, car call) for Station Elevators only.

    e. Car Occupied (indication) for Station Elevators only.

    f. Alarm (indication) for both Station and Parking Structure Elevators.

    g. Elevator shutdown (control and indication) for both Station and Parking Structure Elevators

8. The controller shall be equipped to provide the indication signals to the EERMS as specified in Article 2.14, Remote Monitoring System.

9. The system shall utilize an automatic two-way leveling device to control the leveling of the car. Leveling range plus or minus one fourth inch under any loading conditions, including cable stretch. Over travel, under travel, and rope stretch shall be compensated for and the car brought level to the landing sill. Car shall not overrun floor and level back in either direction.

10. All options or parameters shall be field-programmable without need for external devices. Programmable settings shall be stored in non-volatile memory.

11. An electro-mechanical switch shall open all power circuits to the driving machine motor and brake. A single ground, short circuit or solid-state control failure shall not prevent the application of the brake.

12. The automatic leveling zone shall not extend more than 12 inches above or below the landing level, nor shall the doors begin to open until the car is within six inches of the landing. In addition, the inner landing zone shall not extend more than three inches above or below the landing. The car shall not move if it stops outside the inner leveling zone unless the doors are fully closed and locked.

13. The elevator controller shall be equipped with a toggle switch to disable the door operator power while still moving the car under independent service from the controller.

14. The controller shall have a brake pick switch and indication that will shutdown the car as soon as possible or at the next landing should the brake fail to release in its intended manner.

E. Elevator Door and Hoistway Door Operation:

1. Hoistway doors and car doors shall:

   a. Open automatically and simultaneously when the car arrives at the destination landing.

   b. Be equipped for readily and independently adjustable door hold open times when car stops for a car or hall call. Main floor door hold times shall be adjustable independently of other floors.

   c. Close after hold open time interval has elapsed and no obstruction has been detected, or when the car is called or dispatched to another landing, or when either the car door close button or a car call is pushed.

2. Activation of the door close button in the car shall cancel door timer and close the doors provided there is no obstruction.

3. All closing times shall be adjustable from five seconds to 30 seconds without exceeding closing force specified herein.

4. Door Dwell Times: Door dwell times shall be adjustable above and below, with initial settings as follows:

   a. Hall Call: 20 seconds

   b. Car Call: 10 seconds

   c. Reopening: 20 seconds

   d. Nudging: 16 seconds

F. Access Requirements: Signals and fixtures shall be as indicated on Contract Drawings and specified herein. Components may be rearranged upon Engineer's written approval. Location and arrangement of fixtures shall comply with Accessibility requirements of the applicable Codes.

1.09 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit complete fully legible shop drawings and data including installation details and printed manufacturer's specifications for elevator car, control system, cable and counterweight system, emergency and safety system, door assembly, door operators, and others as required. Text font type and size shall be uniform throughout the set of shop drawings. Shop drawings and details shall include the following:

1. Car interior panel, reflected ceiling, flooring, and base material specification.

2. Signal Fixtures: Control buttons and lamps.

3. Hoistway Entrance: Hoistway and car doors, sills and sill supports for hoistway and car as indicated, door operators, drive and clutches.

4. Elevator doors and door operators. Provide components, layout detail complete with fastenings, etc.

5. Weights of car and hall doors.

6. Indicate direction of stainless steel directional grain.

7. Paint schedule.

8. Wiring diagrams.

9. Complete power, control, and indication schematic diagrams. Provide wiring list and connection diagrams. Diagram shall include interface connections to the external system circuits, such as fire alarm, telephone, CCTV, EERMS and Station Agents Booth. Provide the installation wiring lists for all devices, detailing each individual cable and wire number, color and terminal designation per elevator, used during the installation.

10. Assignments of all processor inputs/output conductors including position indicating system.

11. Traveling cables: Provide details of the traveling cable attachment on both ends.

12. Detail machines and drives sheave(s).

13. Car and counterweight guide rail supports and deflector sheave supports.

14. Car Motion Sensor and elevator camera.

15. Limit switches and mounting detail.

16. Details of hoistway. Verify that auxiliary machine spaces located at the top of the hoistway shall have clear headroom of not less than 60 inches.

C. Engineering Data Including Design Calculations:

1. Submit separate data sheets for machine room heat release calculations based on 30 round trips per hour for two hours, power requirements, conduit fill, and car and counterweight guide rails and supports. Power requirements shall indicate maximum and average power demands, and requirements for emergency power operation.

2. Structural design calculations for car and counterweight assemblies, car and counterweight guide rails and supports, machine assembly and machine beam bed plate supports and deflector sheave supports. Design calculations shall be performed by a Civil or Structural Engineer currently registered in the State of California.

D. Samples: Provide samples of materials and finishes exposed to public view. Include the following items:

1. Car finish floor, 12 x 12 inch panel.
2. Car finish wall and ceiling surfaces, 12 x 12 inch panel.
3. Buttons, switches and lamps.
4. All Braille signs, full size.
5. Traveling cables, 12 inches long.
6. Stainless steel for Car Operating Panel, 4 x 4 inch.
7. Glass, 6 x 6 inch.

E. Product Data:

1. Submit manufacturers' design data and material specifications for all parts and equipment. Specifications shall include test methods required to verify compliance with specifications.
2. Product data for lubricants, sealers, paints, solvents and potentially hazardous substances shall be submitted for Engineer's review. The Contractor shall submit the necessary Material Safety Data Sheets (MSDS).

F. Submit a Test Program for approval with a test schedule and test procedure format for every representative type of test indicated in Article 3.03, Field Quality Control.

G. Test Reports: The Contractor shall submit a complete report describing the detailed results of each regulatory test.

H. Maintenance Program: The Contractor shall submit revenue service maintenance program showing functions to be performed and their scheduled frequency.

1.10 SPARE PARTS

A. General: Spare Parts shall be provided in accordance with Section 01 78 44, Spare Parts and Maintenance Materials, augmented by the following provisions.

B. Spare parts shall become the District's property and shall not be used by the Contractor for maintenance.

C. A "set" is the number of parts required for one fully operable elevator.

D. Recommended Spare Parts List: Submit for approval a List of recommended spare parts necessary to support maintenance for a period of two years. The Engineer will review the List, assign a District Stock Number to each item and return the List to the Contractor. The Contractor shall incorporate the District's Stock Number and resubmit the List, together with two additional sets of bar code labels to the District.

E. Minimum Required Spare Parts List. The Contractor shall provide at a minimum the following spare parts for each elevator installed:

1. Controller components as recommend by manufacturer: One set of each printed circuit board, relays, and fuses as approved by Engineer.
2. Car and hall buttons and lamps, arrival gong lamps: Two sets.
3. Car fluorescent lamps: Four each.
4. Limit switches: Two each.
5. Rollers for roller guides: Two of each size.
6. Gibs: Two of each size used.
7. Door Astrigal material: Four sets.
8. Pana 40 door edge complete assembly with controller and cables.
9. Door clutch assembly.
10. Hall door lock assembly.

F. Delivery: Notify the Engineer in writing 72 hours prior to any delivery. The notification shall identify the specific parts to be delivered. All spare parts shall be delivered no later than 30 Days prior to the final acceptance of the elevator.

1.11 OPERATION AND MAINTENANCE DATA

A. Submit the following in accordance with Section 01 78 23, Operation and Maintenance Data prior to Acceptance.

1. Operation and Maintenance Manuals may consist of off-the shelf manuals as described in Section 01 78 23, Operations and Maintenance Data. However, the manual shall include a separate chapter or volume to identify the unique items and installations that are unique specifically to the Contract, that is covered in the off-the shelf manuals. This chapter shall meet the requirements of system manuals as specified in Section 01 78 23, Operations and Maintenance Data, excluding articles 1.12C, 1.12D and 1.12E. This chapter and its content and wiring diagrams shall be provided in electronic format as specified in Article 1.11 of 01 78 23.
2. Wiring Diagrams: One laminated set mounted in machine room, and three full size sets delivered to the Engineer. Wiring diagrams shall be “As Built”, specific for this installation, and reference identification on drawings shall match points identified on terminals of controllers (wire lists are not acceptable). Wiring diagrams shall include interface and schematic diagrams.
3. Maintenance Tool and Software Manuals: Furnish maintenance tools and supporting software documentation required for the complete maintenance of the

entire system including diagnostics and adjustment. Maintenance tools may be hand held or built into control system and shall be neither of the type requiring recharging or reprogramming nor of the automatic destruct type. The tool and supporting software may be programmed to operate only with this project's identification serial number.

1.12 MAINTENANCE SERVICES

A. Maintenance Program: Within 90 Days after the Notice-To-Proceed and prior to installation, Contractor shall submit a detailed maintenance program showing function to be performed and their schedule. The maintenance program shall include preventive maintenance, trouble call service, and emergency repair service during the Maintenance Period. The maintenance program shall include all work and materials needed to keep the equipment in perfect operating condition. Contractor shall coordinate and perform maintenance in a manner to result in minimum inconvenience to the public.

B. Maintenance Period

1. Contractor shall perform preventive maintenance and any repairs on the elevator due to equipment failure for a period of twelve months after Substantial Completion and the unit is opened for public use. During the Maintenance Period, Contractor shall provide complete preventive and corrective maintenance on all components and assemblies of elevator. At the end of the 12 months Maintenance Period, the District may extend the maintenance period by an additional two years. If the District exercises this option, the Contractor will be compensated in accordance with the corresponding bid schedule line item. The District reserves the right to terminate the Maintenance Period at any time, upon giving 30 Days' notice to the Contractor. Contractor will not be relieved of maintenance until Relief from Maintenance is granted by the District.

2. Maintenance service shall not be subcontracted by shall be performed by or supervised by the Contractor's qualified CCCM personnel.

3. Maintenance shall include all labor and materials need to achieve and maintain minimum 96 percent reliability for the equipment. Contractor shall coordinate and perform maintenance in a manner to result in minimum inconvenience to the public.

4. At the completion of the Maintenance Period, the equipment shall receive a final inspection performed jointly be the Contractor and the District representative. All discrepancies identified shall be corrected at no additional cost to the District. The term of the Maintenance Period shall be extended to provide sufficient time required to clear all identified discrepancy items as approved by the Engineer at no additional cost to the District.

5. The maintenance service will not be required to cover adjustments, repairs, or replacement parts due to misuse, abuse, or vandalism.

6. The Contractor shall maintain local inventory of all wearing parts of the elevator system. Only genuine OEM parts and supplies used in the manufacture and installation of the original equipment shall be provided.

7. Contractor shall obtain written approval from the BART administrator prior to replacing parts.

8. Contractor shall provide and maintain up-to-date compete list of personnel who access the District assets. The list shall include names and 24-hour contact information, including phone numbers.

C. Trouble calls during maintenance period

1. For any trouble calls the District will notify the Contractor of the incident. The Contractor shall be on site with four hours. The Contractor shall notify the designated BART Elevator/Escalator Maintenance representative upon arrival to the site, and check out upon completion of the trouble call. BART personnel may observe the repairs or adjustments made by the Contractor's personnel.

D. Elevator Access:

1. For routine maintenance, The Contractor shall request access to the elevator and coordinate access with the BART Elevator/Escalator Maintenance Department representative.

2. When routine maintenance is being performed, the Contractor shall be prepared to return the elevator to service upon request by a patron if it would take the Contractor 15 minutes or less to do so. If the Contractor cannot return the elevator to service in 15 minutes or less, then the Contractor shall assist the Patron in contacting the Station Agent for Assistance.

E. Work Hours for Maintenance:

1. Repairs required to return equipment to service shall be accomplished as soon as possible during revenue and non-revenue hours.

2. Routine maintenance, non-urgent repairs, and warranty work shall be performed on no more than one elevator at a time at a station or adjacent station. Routine maintenance shall not be performed during revenue peak hours. Routine maintenance may also be performed during non-revenue hours. Refer to the Contract Specification for a definition of revenue peak hours and non-revenue hours for the station.

F. Inspection during Maintenance Period:

1. Contractor shall perform systematic inspection of each elevator system every two weeks and perform adjustment and lubrication of elevator equipment when required as recommended by the manufacturer. Replace defective parts with new parts of same manufacture as required.

2. There will be an annual permit inspection schedule by and at the expense of the District.

3. BART will monitor Contractor's work by whatever means are deemed necessary, including employing others to inspect and/or test the equipment condition and the maintenance work quality.

G. Elevator Shutdowns:

1. Should an elevator become inoperative, the Contractor's service representative shall physically attend to the elevator within four hours of notification of a failure. If the failure occurs after 8:00PM, the service representative shall be onsite no later than 7:30 AM the following Day. The schedule shall apply seven Days per week, 52 weeks per year. The elevator shall be returned to service as quickly as possible.

2. Should there be a failure to comply with above, time requirements, a penalty of $500 shall be assessed for each hour delay.

H. Final Service and Inspection:

1. Two weeks before expiration of the Maintenance Period, or extended maintenance as applicable, the equipment shall be lubricated, fully serviced, adjusted to the standards designated herein and safety devices and emergency service operation shall be checked. Contractor shall re-lamp elevator car light fixture and pit light fixtures. A complete inspection will be performed jointly by the Engineer or District representative and Contractor's representative. All deficiencies shall be corrected. Any deficiencies not corrected shall result in the extension of the maintenance services until the deficiencies are corrected at no additional cost to the District.

I. Contractor will not be responsible for cleaning and repair of elevator car walls and hoistway entrances, except if service required is due to detective materials or improper installation. Service personnel shall clean oil and grease residue from maintenance or repair.

J. The Contractor's technicians responding to trouble calls or performing Preventative Maintenance shall contact the designated BART Elevator/Escalator Maintenance representative and provide the following information: worker's name, date, arrival time, total time spent on site, parts inspected, adjustments made, parts replaced, and detailed description of the work done.

K. Keep a work log on each elevator with the following information: Worker's name, date, time arrived, total time spent back in service time, parts inspected, adjustments and work done, and parts replaced. Every visit, regardless of purpose, shall be recorded in the log. The work logs will be regularly reviewed by the Engineer.

L. Chargeable Repairs: Contractor will not be responsible for the cost associated with trouble calls that are due to misuse, or accidents, or are otherwise not caused by the Contractor. Calls which result in adjustment of safety devices not accessible to the public will not be reimbursed. Contractor shall submit all documentation necessary to

prove that a particular trouble call should be a Chargeable Repair. Contractor shall submit all documentation necessary to justify the direct costs incurred for chargeable repairs and detail charges in accordance with the schedule of service prices submitted and approved by the Engineer prior to the start of the maintenance period.

1.13 RELIABILITY

A. Definitions:

1. Break-in Period: The initial period of operation of the elevator. There shall be only one break-in period for the elevator, regardless of maintenance or modification or other work done on the elevator before, during, or after the break-in period.

2. Failure: An incident which is corrected by replacing a part, resetting the unit, or making an adjustment. Exceptions to failure are conditions of misuse, vandalism, accidents or negligence not caused by the Contractor.

3. Incidents: An incident is any elevator stoppage, regardless of cause.

4. Pattern Failures: The occurrence of multiple independent failures of the same primary replaceable item or adjustment in identical or equivalent applications.

5. Reliability Demonstration Test (RDT): A test to determine a reliability-associated parameter, such as available operating time, within defined statistical risks or with a specific statistical confidence.

B. Requirements:

1. The Break-in Period shall begin after the installer has satisfactorily completed the elevator installation, obtained State operating permits and the Engineer has performed and approved substantial inspection of the elevator. The elevator shall be barricaded and operated continuously under no load condition for a minimum of 48 hours. Upon a continuous, 48-hour operation without incident, the barricades may be removed and the escalator may be put into service to be used by the public.

2. After the Break-in Period, the Reliability Demonstration Test (RDT) shall begin. The escalator shall operate up to full load under normal modes of operation in either direction and be able to provide minimum 96 percent reliability as determined by the following formula:

   Percent Reliability = T/A

   T = Actual aggregate operation time for the escalator, Downtime for scheduled preventive maintenance and incidents, which are not failures, shall not be deducted from the aggregate operation time.

   A = Aggregate revenue operating time of the respective BART station, nominally 20 hours per day.

3. Contractor shall take corrective action to eliminate pattern failures, regardless of total operating time accumulated. The Contractor shall notify the District's Engineer or designated Elevator/Escalator Maintenance representative that an elevator undergoing corrective maintenance is ready to be returned to service to ensure appropriate time tracking for the purpose of accurately tracking the reliability percentage by using formula above. Failure by the Contractor to report "returned to service" will result in lower reliability performance and will remain the responsibility of the Contractor.

C. Contractor shall:

1. Collect the data and document the results of the RDT, perform all calculation, and issue the results.

2. Review all failure incident reports to ensure that only pertinent failures are included in the test results.

3. Review the data the District at interim stages of the RDT and at the final stage, prior to issuing the results.

D. If the District determines that the RDT has fallen below the 96 percent goal for any consecutive 30 Day period, the Maintenance fee due to the Contractor for the 30 Day period shall be reduced by the following formula:

A = MF * Percent Reliability

A = Amount due to Contractor

MF = Monthly Maintenance Fee for one elevator

Percent Reliability = As calculated above

E. Prepare and submit reliability and maintainability reports.

1.14 PERMITS

A. Refer to General Conditions Article 7.4, Permits and Licenses, for the Contractor's responsibility to obtain and pay for necessary permits including permit to complete. Contractor shall submit any required drawings and design calculations to State of California Elevator Division and a copy to the Engineer. The Contractor shall pay for all Elevator Division's inspections, as applicable including those occurring during the Maintenance Period.

PART 2 – PRODUCTS

2.01 GENERAL

A. The general system description for the elevators, which include elevator make and type, number of stops, car and hoistway door and operators configuration and design, controller type, dimension of car floor and enclosure shall be as indicated.

B. Weatherproofing: Metal surfaces shall be hot-dipped galvanized, except nonferrous metals and stainless steel. Machined and operational areas shall be protected from corrosion by applying a rust preventative compound, oil or grease. Refer to Article 2.12, Electrical Components, for related requirements.

2.02 MATERIALS

A. Sheet Steel: ASTM A1007/A1008M, uncoated, pickled.

B. Fasteners: All hardware, including nuts, bolts, washers, screws, and other fasteners shall be stainless steel throughout, including any concrete anchors. Provide all fasteners necessary for proper erection and assembly of work.

C. Stainless Steel: Type 316, unless Type 316 does not exist for a particular item. Type 304 may be used only as approved by the Engineer.

D. Structural Steel: ASTM A36 for car platform and sling. Hoistway entrances struts, headers, etc. shall be galvanized.

E. Aluminum: ASTM B209, B211, B221, and B308/B308M. ANSI 6061 or alloy and temper best suited for anodizing finish specified.

F. Engraving on stainless steel panels:

1. Size: As indicated.

2. Color: Backfill with black epoxy paint, except text and symbols for fire or emergency service shall be red epoxy paint.

3. Typeface: Univers 65 or Helvetica.

G. Grout: Non-staining, nonshrink as specified in Section 03 61 11, Non-Shrink Grout, and appropriate to application:

2.03 FINISHES

A. Stainless Steel, Grade 316, Exposed to View by Public: Satin, vertical directional grain or as indicated, NAAMM AMP No. 4 finish. Sanding medium shall not deposit particles in the grain that are capable of rusting. Provide NAAM AMP No. 4 finish on stainless steel not exposed to view when indicated.

B. New cast or machined non-stainless metal parts, including sling, counterweight frames, sheaves, brackets, non-stainless steel, sub floor, and similar parts which are not exposed to view and not specified to be galvanized shall be cleaned, primed and painted as follows:

1. After fabrication and immediately before shop painting, ferrous metalwork shall be power-tool cleaned in accordance with SSPC-SP-3 to remove mill scale, rust, grease, oil, and any other foreign matter. Welds shall be thoroughly wire brushed.

2. After power-tool cleaning and just before shop painting, ferrous metalwork shall be washed with solvent to remove dust and residue in accordance with SSPC-SP1. Metal work shall be coated with 100 percent Zinc Thermal Spray per AWS C2.3M/C2.23, NACE No. 12, SSPC-CS 23.00.

3. Immediately after cleaning and solvent washing, ferrous metalwork shall be shop painted with one coat of corrosion resistive metal primer and finish coat of gray enamel paint.

C. Pit floor and walls up to level of first landing shall be painted gray with the Epoxy Floor Paint System specified in Section 09 91 00, Painting.

D. Entire hoistway, except pit area, shall be painted white with Semi-Gloss Finish Paint System in accordance with Section 09 91 00, Painting, as applicable to substrate. Raceway and other pre-finished items shall be painted to match.

E. If not otherwise indicated on the Contract Drawings, Machine Room floor shall be painted gray with the Epoxy Floor Paint System specified in Section 09 91 00, Painting.

F. If not otherwise indicated on the Contract Drawings, the Machine Room walls and ceiling shall be painted white with Semi-Gloss Finish Paint System in accordance with Section 09 91 00, Painting, as applicable to substrate.

2.04 HOISTWAY CONSTRUCTION

A. Hoistway shall be constructed of non-combustible materials with the fire rating required to meet the applicable Codes requirements of the building but shall be a minimum of two-hour fire rated construction.

B. The top of the hoistway shall be enclosed and watertight.

C. The minimum vertical distance in the refuge area between the top of car enclosure and the overhead structure or other obstruction shall be not less than 60 inches when the car has reached its maximum upward movement.

D. Hoistway shall be vented with a louver of a minimum three square feet as indicated on the Contract Drawings. Refer to Section 08 90 00, Louvers and Vents.

E. Hoistway shall have a floor drain or sump with drain as indicated on the Contract Drawings. Drains shall be connected to the Station’s industrial waste line or as indicated on the Contract Drawings. Sump covers shall be of galvanized grating that is mounted flush with the floor. Grating shall be removable and have openings not to exceed one inch.

2.05 MACHINE ROOMS

A. Machine room and auxiliary machine spaces shall be sized to accommodate the elevator and related equipment with ample space for maintenance and replacement of all equipment located in the machine room. The machine room area shall be at

least 150 percent of the square footage required by NEII-1 or as indicated on the Contract Drawings.

B. Machine rooms shall be equipped with smoke detectors as specified in Section 28 31 00, Fire Detection and Alarm Systems. Detectors shall interface with the elevator controller via the main fire alarm panel.

C. Refer to the Contract Drawings for machine room ventilation or air conditioning provisions.

D. Refer to Section 10 40 00, Safety Specialties. Provide a rechargeable 10-pound, 4A-60B:C fire extinguisher with metal mounting bracket.

2.06 EQUIPMENT IN HOISTWAY AND MACHINE ROOM

A. Geared Traction Machine: Single worm geared traction type with motor, brake, worm, gear, drive shaft and gear case mounted in proper alignment on isolated heavy structural steel bedplate. Machine shall have ball or roller bearings, and meeting testing requirements without external cooling appurtenances. Run/Stop switch to be in close proximity to each drive. The machine shall be provided with an electromechanical brake. The brake shall be spring applied and electrically released. Swivel type brake shoes shall be applied to the braking surface simultaneously and with equal pressure by means of helical compression springs. The brake electromagnet shall be designed for quick release to provide smooth and gradual application of the brake shoes. Provide an indication to the controller that the brake has fully released, by means of a micro switch. Provide necessary circuitry and devices to provide an indication to the controller to disable power to the machine drive in the event the brake does not fully release and display the related fault. The brake setting and method of measurement shall be permanently marked on the driving machine. Braking surfaces shall be protected from leaking machine fluid.

B. Provide heavy duty AC motor, 480 Volt, three phase, with drip proof enclosure and heavy duty, specifically designed for Traction Elevators rated for minimum 120 starts per hour, continuous duty. Motor shall be high slip 10-13 percent for Station Elevators and low slip two to five percent for Parking Structure Elevators. Motor horsepower shall be minimum 15 horsepower with self-resetting internal thermal overload and speed encoder.

C. Guide rails: Contractor shall provide minimum 18.50 pounds/foot for the counterweight and main guide rails and necessary bracketing/supports

1. The guide rails shall be accurately machined standard elevator industry “T” section guide rails with tongue and grooved joints for the car and counterweight, weighing not less than that specified in the ASME A17.1.

2. Machined splice plates min. one and a half inches thick shall be used to form the rail joints. Each splice plate shall be located so it will not interfere with the brackets and clips and not coincide within 24 inches of any car guide rollers when car is stopped at any landing.

3. Guide rails shall extend from the pit floor to the underside of the machine room floor at the top of the hoistway. Extend rails to the overhead as close to the hoistway ceiling and/or the machine assembly and/or deflector sheaves, as set forth in ASME A17.1 Section 2.23.8. A galvanized structural steel channel mounted to pit floor shall support guide rails and buffer.

4. Guide rail sections shall not be welded together or welded to mounting brackets.

5. The maximum lateral deflection of elevator guide rails shall be one half (0.5) inch.

6. Bottom three feet of the guide rails from the pit floor and brackets shall be painted with anti-corrosive paint or epoxy.

7. Elevator pit ladder shall meet Cal/OSHA requirements.

D. Guide Shoes shall be of the heavy duty roller type guides that are rated for minimum load of 10,000 pounds. Each roller guide shall consist of, as a minimum, a set of three sound-reducing neoprene wheels with precision type ball bearings and held in contact with the rail surfaces by means of adjustable spring loaded devices. Roller guides shall run on dry, unlubricated guide rails. Top of car and all of the counterweight guides shall be fitted with guards. Roller guides shall be securely bolted to the car frame at top and bottom with stainless steel fasteners and shall be properly aligned to be plumb in respect to rail surface. Roller guides shall provide smooth and quiet elevator operation. Balance car to ensure equal roller guide pressure will not to exceed manufacturer's recommendations. Provide a half inch minimum thickness retainer plates at the top and bottom of the car and counter weight frame. Nominal roller diameters shall be as follows:

Car	Counterweight
Minimum diameter six (6) inches	Minimum diameter four (4) inches

E. Hoist and Governor Ropes: Size and number to ensure proper wearing qualities and performance. Minimum eight strands wound around hemp core. Preformed wire ropes shall be installed. Minimum size of hoist ropes shall be a half inch and governor ropes shall be three eighths inch.

F. Buffers: Buffers shall be of the spring type specifically designed for elevator applications and sized per code requirements. Buffers shall be supported by a galvanized structural steel channel that is mounted to pit floor.

G. Counterweight: Sectional metallic weights securely fastened in structural frame. Provide a half inch minimum thickness retainer plates at the top and bottom of the counterweight frames to span the guide rail machined surfaces for its full-finished distance. The elevator shall be suitably counterbalanced for smooth and efficient operation per Controller manufacturer's recommendations. Cast iron or steel weights shall be contained in a steel frame equipped with roller guides. A minimum of two rods shall pass through from the top to the bottom member of the counterweight assembly and filler weights. The filler weights shall be restricted from movement in the frame assembly when proper counterbalance has been determined. The

counterweight assembly shall equal the weight of the complete elevator car plus approximately 40 percent of the rated elevator load or as determined by the Controller manufacturer. A counterweight guard shall be installed at the bottom of the hoistway, according to the applicable code sections. Provide intermediate support brackets on the counterweight guide rails, as set forth in ASME A17.1, Section 8.4.8. Provide the necessary number of brackets so that the counterweight frame shall be within two brackets at all times. Intermediate brackets shall be minimum five eighths inch thick by five inch wide material.

H. Safeties: Flexible guide clamp type shall be mounted on underside of the car frame.

I. Emergency Stop Switches: Provide emergency stop switches in hoistway pit and auxiliary machine spaces and located as required by State codes. Stop switches shall be heavy-duty watertight, red-colored, mushroom-type push/pull switch.

J. Hoistway Limits: Provide terminal and directional limit switches, access limit switches and final limit switches. Limit switches shall be heavy duty with NEMA 4 or 4X housings and heavy-duty mountings, fully adjustable plus/minus six inches minimum.

K. Ceiling height in the machinery room shall be a minimum of nine feet above finished floor.

2.07 HOISTWAY ENTRANCES AT ALL LEVELS

A. General: Fabricate finish work smooth with flush surfaces and free from warps dents, scratches, and buckles.

B. Hoistway doors shall include door unit frame, flush sills, strut angles, headers, hanger covers, fascia plates, toe guards, dust covers, and required hardware. Exposed surfaces shall be stainless steel. All structural steel shall be galvanized. All fasteners shall be type 316 stainless steel. Refer to Article 2.08, Car and Hoistway Doors, herein.

C. Frames: Fabricate from minimum 12-gage, type 316 stainless steel, No. 4 brush finish with side jambs in one continuous piece from sill to head section. Head and jamb fully welded mitered corner.

D. Front Return Panels: Provide full height, 12-gage, type 316 stainless steel No. 4 brush finish.

E. Hangers and Tracks: Provide heavy-duty hangers and tracks that are sheave type with minimum two-point suspension to support the heavy vision panel doors. Provide steel sheaves with ball or roller bearings with resilient sound-absorbing tires and adjustable upthrust, flanged groove tracks. All material shall have anti-corrosive treatment. Maximum load per hanger shall not exceed 100 pounds. Additional hangers shall be provided as required. Hanger bolts shall be a minimum one half inch in diameter.

F. Headers, Struts and Closer Angles required for entrance installation and door closer mechanism, manufactured from plate steel. Use full-length steel struts. Hanger

headers, minimum one-fourth inch thick material, extending from strut to strut with minimum three-eighths inch thick angles. All metal parts shall be galvanized.

G. Dust and Hanger Covers: Provide as required, 16-gage minimum, type 316 stainless steel, No. 4 finish. Hanger cover plates shall extend full length of door track at each landing. Provide key-hole slots at fastening points for easy removal of covers.

H. Fascia, Toe and Head Guards: Minimum 16-gage, type 316 stainless steel, No. 4 brush finish, reinforced.

I. Sills: Provide sills constructed of extruded nickel silver alloy with non-slip surfaces and grooves suitable for guides. Installed sills shall be continuous from strut to strut. Welded parts are not acceptable. Mount the sills with recessed, flat head stainless steel screws or hidden “T” type fasteners. Provide a 16 gauge stainless steel plate to cover the exposed vertical face of the elevator door sills. Provide all support angles, levelers and necessary concrete filler under sill and grouting for a complete secure, level, and plumb installation. No plywood shall be used under the hoistway sills. Apply silicon caulk around all gaps and on top of the fasteners to prevent any liquid from seeping into the underlayment or hoistway edging angle. Support angle and levelers shall be galvanized or stainless steel. Sill shall be supported over its entire length and width.

2.08 CAR AND HOISTWAY DOORS

A. General: All hoistway and car elevator doors shall be stainless steel with vision panels.

B. Door Panels: Car and hoistway door construction shall be reinforced structural steel with minimum 14-gage Type 316 stainless steel, No. 4 brush finish cladding, flush design, rolled profile, rigid construction to ensure rigidity. Cladding shall wrap around all edges. The door panel assembly and related equipment shall be designed to withstand the force requirement of ASME A17.1.

1. Provide full-length neoprene astragals on meeting door faces.
2. Mount doors on structural header, not on car enclosure.
3. Provide non-vision side wings of type 316 stainless steel, No. 4 brush finish.
4. Use torsion spring mechanical closures; do not use weight closures.
5. Door mechanisms shall not be visible in vision panels.
6. Exposed vertical door corners shall be smooth and seamless.
7. Full height 12-gage stainless steel, fixed front return panels.
8. A liquid tight splash guard shall be provided to protect area behind, COP, between COP and door sills. Splash guards shall be 18-gage, 304 stainless steel, sealed at bottom and sides, and shall extend from floor to 48 inch min. above floor, both sides of door opening areas.

9. Provide rubber stops to limit travel of all doors in both directions.

C. Door protection: Refer to Article 2.09, Electronic Door Edge Sensor.

D. Door Guides: Door panels shall be guided at bottom with adjustable nonmetallic gibs sliding in a smooth threshold groove. Provide a minimum of two gibs per panel located one inch from each end. Gibs shall be secured with minimum two screws to bracket and bracket shall be secured to door with at least three stainless steel screws.

E. Vision Panels: Vision Panels shall be installed in such a way that vision panels on car and hoistway shall be aligned. Door vision panels shall be provided and installed in accordance with the following:

Vision Panel shall be minimum 10 inches wide and center mounted. The top of the vision panel shall be 60 inches above finish floor and the bottom shall be 18 inches above finish floor. The glass vision panels shall meet ANSI Z97.1 and CCR Title 8, Elevator Safety Order Section 3034 requirements.

1. Glass: Glass shall be ASTM C1048, Kind FT, Type I, Class 1, Quality q3, meeting ANSI Z97.1. The rating of the glass shall be visible in each panel. Lamination inner layer of 0.060 inch polyvinyl butyral. Both glass layers shall be tempered, clear, nine sixteenths inch total thickness and shall be coated with anti-graffiti clear film coating.

2. Glazing Setting Blocks and Spacers: ASTM C864, semi-hard neoprene or vinyl rubber, 70 to 90 Shore A hardness when tested in accordance with ASTM D2240, of width equal to thickness of glass and long enough to limit load on each block to 15 pounds per square inch gage. Minimum length of setting blocks shall be 3 inches.

3. Glazing Gaskets: Continuous, closed-cell, extruded neoprene manufactured for glazing in type of metal doors and frames. Color shall be black. Gaskets shall be capable of being compressed 40 percent of original size and shall have 100 percent recovery capability when tested in accordance with ASTM F36.

F. Hangers shall to be mounted to the doors with minimum one half inch diameter bolts. Maximum load per hanger shall not exceed 100 pounds, additional hangers shall be provided as required. All fastening shall be stainless steel. Finish of all door equipment shall be galvanized, or plated.

G. Door Operator: Door operator shall be heavy-duty, closed loop speed regulated, by G.A.L. Model MOVFR manufactured by GAL Inc., a Designated Matching Product. Structural support shall be independent of car enclosure. Door equipment and coverings shall be galvanized, or plated. Wire relating cables shall be stainless steel.

1. Test switches shall be provided for the set-up and calibration for opening, closing, nudging and speed zone. At least one hand-held programming tool shall be provided per elevator.

2.09 ELECTRONIC DOOR EDGE SENSOR

A. The door edge sensors shall be District Matching Product (DMP); “Panta 40 Plus” manufactured by Janus Elevator Products, Inc., and shall be installed in accordance with the manufacturer recommendation. Install the door edge sensors along the edge of elevator doors outside of the car door frame structures, minimum 6 mounting brackets.

B. Operation: The door edge sensor shall provide a full light curtain door protective system which does not rely on physical contact with, or the motion of, a person or object to inhibit door movement or initiate door reversal.

1. The system shall be able to detect a two and a half inches diameter rod introduced at any position within the door movement and between the height of one inch above sill level and three inches below the car doorjamb.

2. Detection of intrusion into the protected area shall cause the doors, if fully open, to be held in the open position and, if closing, to stop and reverse to fully open position.

3. The first intrusion during a stop at any landing shall cancel the normal dwell time and substitute a door protective system time delay that shall be adjustable between one to 60 seconds commencing with removal of the intrusion. If, during this period, a further intrusion occurs, upon its removal, the same delay period shall apply and this cycle shall continue until traffic through the doorway ceases.

4. The doors shall commence to close immediately after the expiration of the determined period once the last intrusion has been removed.

5. If doors are prevented from closing for an adjustable period of 15 to 45 seconds, they shall proceed to close at reduced speed and a nagging buzzer within 75-85 decibels shall sound. Door closing force shall not exceed two and a half pounds-force when door re-opening device is not in operation.

6. If the system incorporates light beams, the light source shall not require the use of incandescent filament lamps but shall operate in the invisible portion of the light spectrum.

2.10 CAR ENCLOSURE

A. General: Provide complete car with appurtenances, appointments, and finishes as indicated. Finish work shall have smooth surfaces and free of buckles, scratches, dents, warps, squeaks, and rattles. Joints shall be light proof. Fasteners shall not be visible except as indicated.

B. Car Walls: Car walls shall be Grade 316 stainless steel, no less than 14 gauge Type 316, NAAMM AMP 503 No. 4 finish, and reinforced structurally at least every 30 inches. Surfaces of the floor support, door guides, and wall panels up to 36 inches above platform shall be cleaned then treated with metal primer and rust prevention compound.

1. Vertical panels shall be reinforced to a minimum height of one foot by a steel plate with a thickness of one sixteenth inch or greater.

2. Reinforce bottom of car wall and underside of door with minimum three by three by one fourth inch galvanized steel angles.

3. There shall be a minimum three-inch cove base around the entire perimeter of the cab, including the door walls. The radius of the coving shall be a minimum of one and a half inches.

4. Wood shall not be used anywhere in the elevator car.

5. Vision panels shall be installed in car walls to align with hoistway walls. An additional handrail shall be provided in front of vision panel if the vision panel is on the side wall. Vision panels shall be constructed in accordance with Article 2.08.E.

C. Contractor shall furnish and install flooring in accordance with Article 2.11, Elevator Floor and Platform.

D. Car Sill: As specified in Article 2.07, Hoistway Entrances at All Levels under Sills. Car sill shall be slightly higher than the finish floor, but not exceed one sixteenth of an inch. Sill and door pocket behind fully retracted door position shall have a smooth, upward curved surface to direct liquid back towards center of sill. Area of sill and door tracks behind door shall be accessible by a half inch diameter steam wand for cleaning and sanitation.

E. Ceiling: Unitized stainless steel construction with emergency exit in accordance with regulatory requirements.

F. Car Ventilation: For all elevator cars, Contractor shall provide exhaust fan with sound isolation mounted on car roof or as per manufacturer’s recommendation. Fan shall be two-speed squirrel-cage exhaust blower rated 200 cubic feet per minute, 120 Vac. Fan speed shall be selected by key switch (keyed to EX513) located in the maintenance panel in the Car Operating Panel.

G. Motion sensor: Contractor’s attention is directed to Article 2.16, Recessed Motion Sensing Unit.

H. Car Lighting: Illumination level inside the car shall be 10 foot-candle measured at the floor level. The related work shall be performed in accordance with Section 26 50 00, Lighting.

I. Emergency Lighting: Provide emergency lighting in accordance with CCR Title 8 and with a minimum five foot-candle level. Provide a charger-inverter battery unit with alarm bell mounted on top of car. The charger-inverter battery unit shall be gel-celled batteries providing 24 volts. Battery shall be sealed and have 10 year service life. The alarm bell shall be a six inch gong and shall be mounted to the battery pack and meet the ANSI code requirements for audibility. The unit shall include a pilot light and test switch, off-on switch, and a terminal strip. Input voltage shall be 115 Vac continuous and the output voltage shall be 115 Vac with a maximum 100 watts

capacity. Loads shall include the car emergency lighting, alarm bell, and the transformer unit for the CCTV camera. Upon outage of normal power, the unit shall, within five seconds, light two lamps of the normal car lighting fixtures. The unit shall have sufficient capacity to keep the lights in continuous operation for four hours including the alarm and CCTV camera for one hour. Provide a readily accessible switch mounted in the service cabinet for testing the unit.

J. Car Operating Panel (COP): Elevators shall have 2 COPs, one located on each side of the door. Each COP shall be a stainless steel panel, with heavy duty, stainless steel spring-loaded hinges or continuous piano hinge that is secured with flush barrel-type keyed latches. Hinged Car Operating Panel when opened shall have a minimum three-inch clearance from the finished floor. Contractor's attention shall be directed to Article 2.15, Signals and Operating Fixtures, for related work.

K. All conduits and wires shall enter elevator car from top down. No penetration through the platform are allowed.

L. Car Sill: As specified in Article 2.07, Hoistway Entrances at All Levels, under Sills. Car sill shall be slightly higher than the finish floor, but shall not exceed one sixteenth of an inch.

M. Handrails: Handrails shall be Grade 316 stainless steel, one and a half inch tube or bar. Contractor shall also provide heavy duty Grade 316 stainless steel mounting brackets, fasteners, and other hardware. Fastening shall be three eighths inch minimum in diameter. Each handrail shall support a minimum load of 200 pounds.

N. Car shall be sound isolated from car frame.

O. Car Camera: Refer to Article 2.17, Cameras, herein.

P. If the Engineer requests, car enclosure shall be pre-assembled at the factory prior to shipment for the Engineer's inspection.

2.11 ELEVATOR FLOOR AND PLATFORM

A. Car Frame and Platform: Provide structural carbon steel frame with anti-corrosion primer and paint with gray finish color. Isolate platform from car frame by rubber pads and provide jacking bolts for pad replacement.

1. Allow recess for installation of finish flooring. Design platform and floor for 500 pounds concentrated live load, and 50 pounds per square foot.

B. Subfloor: Shall be constructed in accordance with BART Standard Drawing MS39, Floor and Wall Details. The stainless steel floor pan shall be 11 gage and extending the entire floor area, including the cove base. Seams shall be staggered so as to not coincide. The floor pan shall be sectioned where required and constructed with watertight seams, fastened to the substrate with stainless flat head screws four inches on center from pan joints and 16 inches center to center. The floor pan fasteners shall be caulked, heads ground flush with pan surfaces and indented pan fasteners shall be covered with leveling compound. Concealed areas behind door returns shall be caulked.

C. Finish Flooring: Refer to Section 09 67 70, Elevator Spray-On Flooring.

D. Wood products will not be permitted anywhere in the elevator car or below it.

E. All gaps and running openings where the platform structure meets the surface of the finished openings shall be within the tolerances specified in the Elevator Safety Orders.

F. Platform floor shall slope so that one quart of water poured onto the wall shall flow towards the car door or car center so that liquid on the floor will not accumulate in the corners or near the floor perimeter of the car. The specified finish floor and stainless steel floor pan shall be constructed with watertight seams. There shall be no ridges or tripping hazards.

2.12 ELECTRICAL COMPONENTS

A. General: Electrical components shall comply with NFPA 70 and CCR, Title 24, Part 3, California Electrical Code. All wiring and conduit work shall be performed in accordance with Section 20 70 26, Common Materials and Methods for Electrical Systems, and Section 26 05 24, Low and Medium Voltage Wires and Cables, unless stated herein.

B. Weatherproofing: Electrical enclosures, penetrations and wiring shall be waterproof, NEMA 4 or 4X for Station Elevators and NEMA Type 4 for Parking Structure Elevators, unless otherwise specified. Wiring shall be in galvanized rigid steel (GRS) conduit with watertight fittings, except otherwise noted.

C. Raceways:

1. Fittings: Provide watertight fittings and hubs for all raceways and enclosures.

2. Provide mechanical protection for lighting fixtures on top and bottom of car, and in the elevator pit. Light fixtures shall be separately switched.

3. Raceways and conduits in hoistway shall be exposed. All conduits shall be galvanized rigid steel and minimum three-fourths inch. Liquid-tight flexible conduit may be routed to fixtures and switches, but shall not exceed 18 inches in length. Main hoistway raceway shall be hinged, NEMA type 12 wireway with zinc plated or stainless steel quick release hatches. Raceway joints shall be gasketed. Raceways shall be powder coated inside and out.

4. All terminal junction boxes in the hoistway and machine room shall be stainless steel, NEMA 4X. Pull boxes shall be powder coated steel enclosures, NEMA 12 or 4 for Station Elevators and NEMA 12 or 4X for Parking Structure Elevators.

5. Electrical metallic tubing (EMT) is not permitted for elevator related work.

6. Conduits shall be routed along walls and ceilings.

D. Electrical Wiring:

1. Wiring shall be color coded and identified with permanent imprinted embossed sleeves at all terminations throughout, including controller and junction boxes. Terminal strips shall be identified with unique numbering.

2. Conductors: Provide stranded copper conductors throughout, with individual wire color coded and/or labeled. Minimum wire size shall be 18 AWG. Conductors shall be designated uniformly throughout the system.

3. External connections to the equipment on each controller shall be made by means of approved cable thimbles or solderless cable lugs or both depending on the current carried (Amps) as approved by the Engineer.

4. Label each terminal and spares as they correspond to the controller schematic. Connections shall use insulated crimp connectors on terminal blocks located in control cabinets and junction boxes. The crimper shall be comparable to Panduit model CT-550 or equal. Do not use splices or similar connections in any wiring except at terminal blocks. No more than three wires per terminal shall be allowed. Provide anti-corrosion protection compound on all high current connections throughout the system using product comparable to Thomas & Betts #CP-16 or equal. All terminations shall be labeled.

5. Do not parallel conductors to increase current carrying capacity.

6. Do not use armored flexible metal conduit as grounding conductor.

7. Perform grounding of the elevator equipment in accordance with the manufacturer’s instructions.

8. Provide dedicated conduits for the following circuits:

   a. Main power from the disconnect to the controller

   b. Motor power from the controller to the motor

   c. Speed encoder to the controller

9. All door interlock wiring shall be heat resistant and shall be continuous without splices or terminations to or from controller.

E. Traveling Cables:

1. Provide two traveling cables between car and the controller via the “half-way box” in the hoistway. The steel support cable shall be flexible or extra-flexible, preformed, galvanized steel wire rope support strand. The steel core shall be insulated with polyvinyl chloride and cotton braided. An overall jacket of polyvinyl chloride (PVC) shall provide a smooth, flexible, abrasion-resistant covering. Cable shall comply with the flame test requirements in Paragraphs 1060.1-1060.9 of UL 1581 and shall be CSA FT-1 flame rated. The insulated conductors shall be soft annealed; bunched stranded, bare copper complies with ASTM B3 and B174. The conductors shall be insulated with a high quality 60

degrees Celsius PVC and shall be rated at 300 Volts in accordance with the requirements of UL62, CSA C22.2 No.49 and NEC Articles 400 and 620. Provide a heavy duty, single eye, closed mesh multi-weave, stainless steel wire grip to support the traveling cable on both ends and properly anchor to relieve strain on individual conductors. Provide details of the cable attachments on each end. Protect cables from rubbing against hoistway or car parts.

2. One traveling cable (for power and control circuits) shall be continuous from elevator car to the controller in the elevator machine room. Provide a minimum of 10 spare conductors of minimum #18 AWG and two spare conductors of #14 AWG, which shall be terminated at both ends to a terminal block.

3. The second traveling cable (for communication circuits and CCTV) shall be continuous from the car to the Communications Interface Cabinet in the elevator machine room via the halfway box. The following cables shall be provided:

    a. Minimum of two pair spare #22 AWG communication conductors terminated to “Krone” style termination blocks.

    b. Minimum of one pair spare #14 AWG conductors terminated to terminal blocks.

    c. Minimum two coaxial cables. The minimum cable count shall be increased to include one spare terminated to feed-through coaxial BNC connectors.

    d. One six fiber cable terminated to fiber patch panel with “LC” style connectors. All cables shall be terminated at both ends. Route the coaxial and optical fiber cables and communication circuits in conduit to the Train Control Room or Communication Room.

4. The coaxial cable shall be 75-ohm exhibiting the characteristics of an RG6 and incorporate the added mechanical properties of a composite copper and copper-covered steel inner conductor, the deformation resistance of a cellular polypropylene dielectric, and a combination foil tape and copper braid for 100 percent shield coverage.

5. Communication circuits shall be a minimum one pair, #14 AWG and six shielded twisted pair, #22 AWG, soft-annealed, bare copper cable with a non-insulated drain wire. The assembly shall be covered with an overall colored nylon or PVC jacket.

    a. Multimode fiber optic cable shall be OM4 cable, or approved equal compliant to the IEC 60793-2-10, Type A1a.3 Fiber and TIA/EIA-492AAAD standard.

    b. 50/125 micron tight-buffered multimode optical fiber coved with high-strength aramid yarn and jacketed with flame retardant polyvinyl chloride.

    c. Operating Wavelength and Bandwidth: 160 MHz·km at 850 nanometers and 500Mhz·km at 1300 nanometers.

    d. Attenuation at 850 nanometers: 3.75 decibels per kilometer maximum.

    e. Attenuation at 1300 nanometers: 1.00 decibels per kilometer maximum.

f. Core diameter: 50 micrometers plus or minus 3.0 micrometers optimized for 550 meters.

g. Cladding diameter: 125.0 micrometers plus or minus 2.0 micrometers.

h. Optical Performance: The attenuation shall be measured in accordance with EIA TIA-455-61. The bandwidth shall be measured in accordance with EIA TIA-455-30 or EIA TIA-455-51.

i. Mean Cycles Between Failures (MCBF) of 40,000 for less the 2 decibels loss.

F. Communications Interface Cabinet (CIC): Provide one or more NEMA 12, powder coated steel junction boxes mounted in a secure location where the District's authorized personnel can access.

1. The cabinet shall be equipped with a 115VAC, 15A breaker connected to four fused terminals and four auxiliary outlets.

2. The cabinet shall terminate the communication and control circuits that are routed between the elevator controllers and other equipment and shall include but not be limited to circuits such as: fire alarm, station agent booth controls and indication, CCTV, emergency phone, remote monitoring signals, and seismic switch.

3. Terminations shall be on a DIN rail mounted terminal strip unless specified otherwise herein, with each termination labeled. System circuits shall be grouped together on separate terminal boards or separated by two spare terminals between different systems.

4. Provide feed-through coaxial BNC connectors mounted on a L-shape channel inside the junction box.

5. Provide conduit from CIC to train control room for communication cables as specified in Contract Drawings.

G. Main Disconnect Device: Provide a heavy-duty fused safety disconnect switch or a circuit breaker capable of being locked in the "OFF" position for each elevator in the machine room. The safety switch shall be sized for the total motor and controller electrical loads. The disconnect shall incorporate a micro switch so that when the disconnect is opened, the lowering device does not operate. The disconnect shall be located adjacent to the machine room door.

H. Car Inspection Station: Provide a car top inspection station to operate the car from the top. The inspection station shall include control switches for up, down, run, inspect, and stop and shall include an audible and visual alarm for emergency service. Inspection station shall also include a gasket sealed light fixture with a 25-Watt compact fluorescent lamp with wire guard, glass globe and switch and provide a 20A, 120V GFCI duplex receptacle with weather-resistant cover and flip-lids.

I. Work Lights and Convenience Outlets: Provide the following:

1. Top of car: 15 Amp, 120 Vac, GFCI duplex receptacle on car top for CCTV camera power supply in weather-resistant outlet box with flip-lids.

2. Bottom of car: Gasket sealed light fixture with a 25-Watt compact fluorescent lamp with wire guard, glass globe and switch and a 20A, 120V GFCI duplex receptacle with weather-resistant cover and flip-lids. Fixture shall be accessible from the lowest hoistway landing.

3. Inside car – 15 Amps, 120 Vac, GFCI duplex receptacle in the car service panel.

4. Hoistway – At the top of the hoistway and in the pit, provide a gasketed, sealed, 48 inch long light fixture with a lamp with wire guard and switch. Light switches shall operate both hoistway light fixtures and be enclosed in weatherproof box with flip-lids. Provide in hoistway pit a minimum of two duplex receptacles (20 Amps, 120 Vac) with GFCI protection in weather-resistant outlet box with flip-lids. Receptacles at the elevator pit shall be installed 36 inches above the pit floor.

5. Elevator Machine Room - Provide a minimum of two duplex receptacles (20 Amp, 120 Vac).

J. Provide the necessary red lockable safety switches to isolate 120 Volt power for auxiliary systems in the elevator car, such as car lighting, cameras and outlets. Mount switches in the elevator machine room adjacent to the controller. At the switches, label the power source and function for each switch.

K. Main Circuit Breaker: If a sprinkler system is installed in the hoistway 24 inches above pit floor or machine room, then the main 480 Volt circuit breaker shall be supplied with a shunt trip feature to isolate the main power supply to the elevator prior to the activation of the fire sprinklers. The shunt trip shall be activated by heat detectors in the machine room and hoistway by means of the main fire alarm panel.

2.13 CONTROLLER

A. General: The work of this section shall be performed in accordance with Section 20 70 26, Common Materials and Methods for Electrical Systems. The incoming AC main feed shall have a line reactor or line conditioner.

B. Controller: The programmable controller shall be a non-proprietary, micro-processor driven, Motion 4000, DMP, for electric traction elevators. Controller shall be equipped, at a minimum, with the following features:

1. Computer controlled motion of the elevator including acceleration, top speed deceleration, and two-way leveling.

2. Serial microprocessor cart-top and COP boards.

3. Fire fighter’s service phase 1 and 2.

4. Hall board serial link.

5. Door operating circuitry for door operations.
6. Motor feedback encoder circuitry.
7. Regenerative drive.
8. Load weighing.
9. Voice annunciation.
10. Rope gripper.
11. Solid-state motor starter.
12. Isolation transformer.
13. Line conditioner.
14. AC motor drive package.

C. Controller Panel: The controller panel shall be provided with a date pocket made of high impact thermoplastic mounted behind the door panel with three point latches and lockable. The controller cabinets shall be NEMA 4X with minimum eight-inches floor stands and provided with the technical data, instruction manuals, and other related materials about the controller enclosed therein. Provide two hand-held programming tools per facility.

D. Refer to Article 1.08, Design and Operation Requirements, under Elevator Controller, for operational requirements.

E. Each controller shall generate external indicating signals required by the remote monitoring system. Provide a terminal block in the controller cabinet and hard wire the remote monitoring system events' list. These event indicating signals shall be available from the termination points, i.e., dry RMS contact relay, such that the specified elevator fault and status event data can be automatically received by the existing District's Remote Escalator/Elevator Central Monitoring System (EERMS).

2.14 REMOTE MONITORING SYSTEM

A. The Contractor shall provide the signals to report any failures or out of service conditions to the existing District's Escalator/Elevator Remote Monitoring System. The existing EERMS was developed and is owned by the District. The EERMS communicates with the elevator controller located in the Communications Interface Cabinet.

B. The Communications Interface Cabinet shall be equipped with Designated Matching Products, Allen Bradley DeviceNet LDX module, Model 1790D-T8BV8B 8 Universal In, 8 Source Out with screw-clamp and Module 1790D-T16BVDX 16 Universal In Expansion Block Screw-clamp and 25 post terminal strip. A 25 conductor cable shall be provided between the controller and interface cabinets for the sole use of the EERMS. Isolation relays for the station agent's elevator controls and indications shall

be provided inside the Communications Interface Cabinet. The EERMS shall be installed and wired according to the Contract Drawings. Provide a Category 6 network cable and DeviceNet thick cable and a dedicated conduit from the Communications Interface Cabinet to the Train Control Room or Auxiliary Communication Room in the station as indicated on the Contract Drawing.

C. Fault and Event List: The controller shall provide the following signals to the DeviceNet modules. These signals shall be reported instantaneously as the controller responds to the initial signal within the elevator system. In the event a monitored condition cannot be determined directly from the controller, the Contractor shall provide the necessary sensor device. The following safety circuits and conditions ("Events List") shall be established for reporting.

1. Door Lock
2. Loss of Power
3. Safety Circuit
4. Emergency Stop Button
5. Emergency Service (Fire Alarm or Earthquake)
6. Car at Top Landing
7. Car at Middle Landing (If applicable). If more than three landings, parallel all intermediate floors and connect as Middle.
8. Car at Bottom Landing
9. In Service (ISV and ISRT signals in parallel)
10. Spare
11. Spare
12. Car Shutdown by Agent
13. Car Occupied
14. Mechanic On-Site (door switch and ISV signal)

2.15 SIGNALS AND OPERATING FIXTURES

A. General: Contractor shall provide fixtures and signals as follows, test complete system, correct any deficiencies in wiring and function and make complete system fully functional. Location and arrangement of fixtures and signs shall comply with the ADA and other code requirements.

B. Push Buttons:

1. Provide stainless steel, vandal resistant push buttons for each landing, door open, door close, car alarm and emergency phone call. Metal button top surface shall be flat and raised one eighth of an inch from surface. Metal buttons for hall call shall be through-engraved with illuminated directional arrows. An illuminated halo shall surround the push buttons. Halos surrounding the alarm and phone buttons shall be red. Button illumination shall be long-life, standard wattage LED. Push buttons for all car and hall, alarm and hands-free phone shall be Innovation Industries Type PB 30 a Designated Match Product (DMP). Push button assembly for non-illuminated functions, door close and open shall be Innovation Industries Type PB-20, a Designated Matching Product (DMP).

2. Operation of hall call button shall cause button to illuminate until car arrives. Operation of car call button shall cause button to illuminate until car reaches other landing.

C. Car Operating Panel (COP):

1. Refer to BFS Standard Drawings for layout and details.

2. COP Faceplates: The faceplate shall be stainless steel, No. 4 finish, one-eighth inch minimum thickness, flush mounted.

3. COP Etchings: Except for pushbutton markings, all text shall be etched in faceplate and back-filled with black paint. Text related to the fire service shall be back filled with red paint. Lettering shall be as large as possible, but a minimum of 1/4 inch, unless otherwise indicated.

   a. Fire Service II instructions shall be etched in red lettering.

   b. The elevator number shall be etched into the faceplate with minimum one half inch, black filled lettering. Elevator identification shall include the Station number for example “A20, Elevator No. 34”. The correct elevator number will be assigned by the Engineer.

   c. “No Smoking” shall be etched with minimum one inch, red lettering.

   d. Elevator capacity shall be etched in black lettering.

4. COP Nameplates: Provide raised Braille Grade II, standard alphabetical characters for numerals or symbols as indicated to the left of the operating buttons and devices used by the public, in compliance with the Americans with Disabilities Act. Raised characters shall be white metal on black background without borderline on edges for Station Elevators and with borderline on edges for Parking Structure Elevators. Braille plates shall be surface mounted on control panel with concealed mechanical fasteners.

5. Fastening shall be flush, stainless steel tamper-proof screws of material matching faceplates.

6. Car alarm button: Provide dry contact for alarm initiation to Station Agent's Booth Annunciation console. Activation of alarm button shall illuminate button, as well as activate car alarm bell.

7. Car Position Indicators: Contractor shall provide a digital programmable position indicator in the Car Operating Panel. The displayed landings shall correlate with the push button nameplates and provide a directional arrow that shall be illuminated only while moving.

8. Exposed key switches shall be provide for the stop switch only. See Article 2.15G. herein for key type.

9. Door shall have a permit holder with a minimum display window size of eight and three quarter (8.75) inches wide and four and a half (4.5) inches high, per standard Drawing No. AS08 Elevator Car Operating Panel Details.

D. Service Cabinets: The Contractor shall provide a service cabinet in the Car Operating Panel. The service cabinet shall be behind a minimum 16-gage stainless steel hinged door with gasket seal. Keying shall be as designated by the Engineer. The service cabinet shall be mounted with hairline joints to car wall surface and have no unfilled openings. The service cabinet shall provide the following:

1. Inspection Service key switch, EX514

2. Independent Service key switch, EX513

3. Car light on/off key switch, EX513

4. Motion Sensor mode key switch, EX513

5. Fan Speed high, off, low key switch, EX513

6. Emergency Light illuminated test button

7. Duplex GFI receptacle

8. Fire service panel and Fire Service keying all EX515.

E. Emergency Car Hands Free Telephone: Contractor shall furnish, install and test hands free telephone as required by Section 27 30 01, Telephone Systems. Provide all work necessary to install the system to satisfactory operation.

1. Telephone panel shall include a text and Braille emergency telephone nameplate.

F. Hall Fixtures.

1. Chimes: Provide single chime for up and double chime for down direction. Chime volume shall be at least 75 decibels measured five feet from the hoistway door.

2. Hall lantern shall illuminate when car arrives. Green for up, and red for down. Provide vandal resistant, long-life LED directional lanterns with stainless steel

faceplate for Station Elevators. Provide extruded white, long-life LED directional lanterns with stainless steel faceplate for Parking Structure Elevators. Provide both “up” (one signal) and “down” (two signals) arrow-shape signals at landings of two-way travel. Light extinguishes when doors close. Lanterns shall not be mounted in the doorjamb.

3. Hall Call Panel: Provide hall call push buttons at each landing as specified herein under “Push Buttons”. Mount in a minimum one-eighth inch thick stainless steel faceplate. Surface mount faceplate with tamper proof fasteners. Hall call stations shall be located on right side of hoistway entrances at single elevator locations and be centered between entrances at group of elevators. Hall calls shall be identified with “Elevator Call” labels below the button. Labels shall include Braille lettering. Main floor hall call panel shall be equipped with fire service key switch and instructions. (Refer to Article 2.15G, Keys and Key-Operated Switches, for specifications for key switch.) Hall call panels at each level shall have the required “do not use in case of fire” instructions. All emergency instructions shall be etched in stainless steel faceplate and back-filled with red epoxy paint. Wording as approved by the applicable Fire Marshal. Pictorials shall be supplied with wording.

G. Keys and Key-Operated Switches: Keys in the car and at hoistway entrance shall be round barrel, Fort Lock EX series keys to match District standard keys. The Engineer will provide specific key assignment. Key-operated switches shall be in compliance with regulatory requirements. Coordinate keyway and keying requirements with the Engineer. Keying shall be compatible with the existing BART lock system. BART keys for key operated switches and locks to be GEM, Fort lock, Chicago, barrel keys. Fire recall key-operated switch shall be on integral hall call fixture at Main floor.

H. Station Agent’s Booth Elevator Monitoring and Control (SABEMC): SABEMC is part of the station SCADA and station agent booth panel. Contractor shall provide signal wires specified in Article 1.08 from the elevator controller to the DeviceNet module in the CIC. Provide a thick DeviceNet cable from the CIC to the SCADA cabinet located in the train control room. Provide conduits and conductors to route required elevator indications and controls to the stations agent’s booth. Conductors for these signals shall be rated for at least 300 Volts, shall have at least four spare conductors, and shall be routed in a dedicated conduit to the station agents booth. Refer to the District Technical Manual – SCADA System Function Description.

2.16 RECESSED MOTION SENSING UNIT

A. The motion sensor shall be the District Designated Matching Product (DMP), CI-200, Version 2, 360o PIR occupancy sensor as manufactured by The Watt Stopper, Santa Clara, CA 95050. The motion sensor unit shall be recessed into the ceiling and routing of the control cable shall be in accordance with the Contract drawings. Provide a mounting bracket flush to the ceiling for the motion detector unit. The motion detector shall be located and adjusted so that movement of the doors does not generate a false occupancy. Provide the 120 Vac-power supply to the power pack unit of the motion detector.

B. Programmed Operation: If after a programmable length of time, of 5 to 90 seconds an elevator car call has not been activated and the sensor detects elevator car

occupancy, the car shall be programmable to proceed with either one of two courses of action. The choice of action shall be selectable by the motion detector key switch in the service panel on the Car Operating Panel. The logic and circuitry of this alarm shall be incorporated into the controller circuit. Any auxiliary relay contact required to accomplish this feature shall be provided. This circuit shall be depicted in the schematic diagram of the controller. All occupancies, regardless of operation, shall be reported to the Station Agent's Booth.

C. Automatic Car Call Mode: Upon occupancy detection, the elevator shall automatically generate a car call to the opposite floor or next floor if a car call is not activated within an adjustable time of five to 30 seconds.

D. Nuisance Occupancy Mode: If an occupancy is detected without a car call for an adjustable time of five to 30 seconds, then the doors shall reopen and remain open with audible alarm until a car call or hall call is generated or the car is vacated.

2.17 CAMERAS

A. General: Provide cameras as specified in Section 28 41 29, Closed Circuit Television Systems. Camera circuits shall be routed through the Communications Interface Cabinet in the machine room and to the Train Control Room or Communications Room via a dedicated CCTV conduit.

B. Car camera: A camera shall be mounted in the ceiling corner on the front wall opposite of the side of the main Car Operating Panel. The camera shall be adjusted to observe patrons operating the main Car Operating Panel. The camera shall be housed in a vandal resistant enclosure.

C. Elevator Entrance Cameras: A camera shall be provided for each elevator entrance. Cameras shall be located at least eight feet above the finish floor and adjusted to view the entire entrance. Outdoor locations shall have a waterproof enclosure.

2.18 SIGNS

A. General: Hoistway and car signs shall be stainless steel plates with black backgrounds and raised white lettering and Braille symbols with raised white borders, unless otherwise specified. Braille lettering shall be CA Grade II, comply with the Americans with Disabilities Act and shall be located below alphabetical characters, numeral, or symbols. Signs shall be on separate plates flush-mounted with hairline joints and concealed mechanical fasteners in cars and surface-mounted with tamper-proof fasteners at elevator entrance locations.

B. Provide stainless steel signs with Braille indicating landing identification on both sides of the door jamb at every landing. Signs shall have black background and white lettering. Lettering shall be two inches in height and centered 60 inches above doorsill. Signs shall be surface-mounted with dimensions of 4 inches by 4 inches with corners of 1/16 inch radius.

C. Provide Star of Life Signs on each side of doorjamb at the main landing. Signs shall be raised blue lettering and standard star of life symbol on a white background.

D. Refer to “Hall Call Panel” under Article 2.15, Signals and Operating Fixtures, herein for requirements for “Elevator Call” signs with Braille at each hall call station.

E. Provide “Station Agent Call” sign with Braille on hands-free white courtesy phones located near elevator entrances to avoid confusion between hall call stations.

F. Provide black laminated plastic sign with one-and-a-half-inch lettering centered on each hoistway entrance header indicating the elevator number. Sign shall be without Braille and abbreviated as the following: “A20, ELEV. 33”.

2.19 VIBRATION ABSORPTION MOUNTS

A. Vibration Isolation: Minimum two-inch thick vibration-absorption mounts, designed to effectively prevent the transmission of vibrations to the structure, and thereby eliminate the sources of structure-borne noise resulting from the elevator system. Indicate vibration isolation material on all drawings.

PART 3 – EXECUTION

3.01 PREPARATION

A. Hoistway: Examine the hoistway and supporting structure, and the conditions under which the elevator work is to be installed. Do not proceed with elevator installations until unsuitable conditions have been corrected. Hoistway pit shall be painted prior to installation of elevator equipment.

B. Electrical: Examine areas to receive elevators and verify that electrical rough-in is correct.

C. Machine Room walls and floor shall be painted prior to installation of elevator equipment.

D. Confirm that applicable submittals have been approved and applicable permits obtained prior to installation.

3.02 INSTALLATION

A. Welded Construction: Provide welded connections for installation of elevator work where bolted connections are not required for subsequent removal or for normal operation, adjustments, inspection, maintenance and replacement of worn parts.

B. Vibration Isolation: Mount rotating and vibrating elevator equipment and components on vibration-absorption mounts.

C. Lubricate operating parts of systems as recommended by manufacturers.

D. Alignment: Coordinate installation of hoistway entrances with installation of elevator guides rails for accurate alignment of entrance with car.

1. Adjust sills and doors to provide smooth, trouble free operation.

2. Ensure guide rails plumb and parallel with maximum deviation from rail center-line of one-sixteenth inch per floor, noncumulative.

3. Install buffers with required blocking and supports.

4. Grout sills with non-shrink grout. Set units accurately aligned with finished floor at landings.

5. Mount sill plate with concealed fasteners.

6. Field repair damaged coatings and wrappings.

E. Controller: External connections to the equipment on each controller shall be made by means of approved cable thimbles or solderless cable lugs, or both, depending on the current to be carried.

F. Balance car to ensure equal guide shoe pressure on all shoes. Do not exceed manufacturer's recommendations.

G. Coordinate with the Engineer to install and test connections between the elevator and the train control room, communications room, and station agent booth as needed.

H. Controller shall have 6 inches minimum clearance on all four sides (not including front and back).

3.03 FIELD QUALITY CONTROL

A. General

1. Notify the Engineer at least five Days prior to each scheduled test. Perform testing in the presence of the Engineer.

2. Regulatory Agencies Inspection: Upon completion of the elevator, Contractor is responsible to provide instruments, weights and personnel to conduct tests required by regulatory agencies. Representatives of the regulatory agencies and the Engineer shall witness tests.

3. Overall elevator testing shall be performed after installation.

4. Contractor shall perform safety tests on the elevator without load. Tests shall be recorded in detail and submitted to the Engineer for approval.

B. Acceptance Testing Requirement

1. The emergency phone, seismic switch, and fire service operation shall be tested prior to the State Inspection to ensure that these devices are communicating as intended with the BART operating system.

2. A one-hour heat and run test with full load shall be performed prior to State inspection. Performance and leveling tests shall be made before and after heat and run test. Heat and run test shall not exceed manufacturer's recommendations.

3. All the Station Agent's Booth signals and functions, and Remote Monitoring System signals and functions shall be tested.

4. Contractor shall conduct NEII-1 performance tests with its own calibrated equipment as approved by the Engineer. Test results shall meet or exceed NEII-1 and shall be submitted to the Engineer for approval. The Engineer may witness tests.

5. Measure and record acoustical output levels in machine room and both inside and outside of car to ensure Contract requirements are meet.

6. Contractor shall test direction indicator system for proper operation.

C. Substantial Completion Inspection: District personnel will perform a full operation and quality control inspection, known as the Substantial Completion Inspection, after the above items had been completed. This inspection may occur prior to or after the State inspection. However, Substantial Completion certificate for the elevator will not be granted until the State issues an operating permit and all significant and most other punch list items identified during the Substantial Completion Inspection have been corrected and approved by the Engineer.

D. Final Acceptance Inspection: After the completion of the punch list items, submission and approval of all deliverables, including the Operation and Maintenance Manuals and training, and the Maintenance Period is near completion, the Contractor shall notify the Engineer at least two weeks in advance to schedule the Final Acceptance inspection. This inspection will verify that the punch list items have been completed and the elevator was properly maintained and is in good working condition.

E. Corrections: Correct all defects or discrepancies at no cost to the District. Should discrepancies be such that re-examination and re-testing is required, the Contractor shall pay for costs including those of the Engineer.

3.04 MAINTENANCE

A. The Contractor shall perform maintenance service for the elevator in accordance with Article 1.12, Maintenance Services.

3.05 CLEANUP DURING CONSTRUCTION

A. The Contractor shall keep elevator area, elevator machine room, and the space allocated to the Contractor's work in a neat, safe and orderly condition.

3.06 FINAL CLEANING OF FACILITIES

A. Refer to Section 01 74 14, Cleaning. Prior to final inspection by the Engineer, and after all elevator work is essentially complete, thoroughly clean facilities including hoistway enclosures and car, utilizing professional building cleaners where appropriate.

3.07 TRAINING

A. Training Program: The Contractor shall provide either a Controller Simulator approved by the Engineer, which will become District property, or a program to train the District's operations, maintenance and training personnel in details of the elevator system components which were installed or modified to enable the District to operate, service and maintain the elevators. In regard to the work of this Section, these provisions supersede Section 01 79 00, Demonstration and Training. As a minimum, training topics shall include controllers, door operators and drive system.

1. The training program shall include formal and informal instruction, as appropriate, and any models, mockups, documentation, and aids necessary to carry out the program.

2. Materials used in the training program shall be of durable construction and shall become the property of the District.

3. Assumptions:

    a. The Contractor shall assume that the personnel to be trained have only the basic skills pertinent to their craft as outlined in the District's job descriptions for the involved personnel.

4. Training Program: The training program shall be submitted, for approval by the Engineer, within 30 Days of Submittal Completion and shall contain, at a minimum, the following data:

    a. A flow diagram indicating the logical progression of training to be conducted.

    b. A description of each course, including the number, description and duration for each lesson in the course.

    c. Resumes showing the qualifications of the proposed instructors. Instructors shall demonstrate a complete and thorough technical knowledge of the material being covered in the course. These instructors shall be thoroughly familiar with handbooks, guides, tools, test equipment, and other aids used in troubleshooting and repairing the equipment.

    d. A list of subcontractors and equipment manufacturers to be used in the training program and a description of their responsibilities.

    e. Complete written and practical tests to be administered at the conclusion of each course module and the grading system to evaluate the proficiency of each trainee. The grading system shall identify needs for further training as needed.

f. Third party training materials that are proposed to be included in the training program.

g. Draft of the training manual.

B. General: The training shall be provided to the District personnel with the operating procedures necessary to operate the systems. The courses shall include, but not be limited to, the following training:

1. Classroom training shall give course participants an understanding of the overall system operation.

2. Hands-on training shall give course participants actual maintenance experience.

C. Courses: Training shall consist of the Elevator System Maintenance Course.

1. The Elevator System Maintenance Course shall provide the District's maintenance workers and trainers with detailed knowledge of and hands-on experience with the system functional capabilities and overall operation in order to properly troubleshoot and maintain the following components: controller, door operators, drive components, signal, and safety devices. The course shall provide participants with a working knowledge of these items and its operation, maintenance, interfaces, and use of test equipment for diagnosing troubles.

2. The course shall provide theoretical background and hands-on experience in troubleshooting and repair procedures to permit participants to locate and repair system faults in a time-efficient manner. Course shall include emergency provisions, including emergency access and procedures to be followed at time of failure in operation and other building emergencies. It shall train personnel in the procedures to be followed in checking the source of operation failure or malfunction. Operation of diagnostic equipment needed shall be explained.

3. The course shall utilize the complete Operation and Maintenance Manual.

4. The course shall utilize actual hardware and photographs taken during the manufacturing process wherever possible. Actual hardware used for training must pass re-inspection and acceptance testing prior to being placed in service.

5. The course shall consist of a minimum of eight hours of classroom training and eight hours of hands-on in the field training. The training shall not exceed 8 hours per day.

6. The course shall be presented a total of four times: The Contractor shall present first session within 60 days after the substantial completion of the first elevator. The final session shall be no later than within 120 Days after the first session.

7. Each class shall accommodate up to 10 participants.

D. Training Location and Classrooms: Training courses shall be conducted in facilities provided by the District. The facilities will be equipped with tables and chairs. The Contractor shall provide video players and projectors as required.

E. Instructors: Contractor shall provide qualified instructors. The instructors shall have previous formal classroom instruction training and relevant experience with the provided systems equipment in an operating environment.

1. The instructor shall present classes and instructions in person.

2. When prerecorded lectures are part of a training course, the instructor shall supplement the recorded material as needed to make it relevant to the actual installation being taught.

3. The instructors shall demonstrate a complete and thorough technical knowledge of the material being covered in the course. All instructors shall be thoroughly familiar with the handbooks, guides, tools, test equipment, and other aids used in troubleshooting and repairing the equipment.

F. Training Manuals and Equipment: Prepare training manuals to supplement the Operation and Maintenance Manuals and submit them to the Engineer for review and approval at least 90 Days prior to the start of classroom instruction. The training manuals shall be prepared specifically for use as training aids. The Operation and Maintenance Manuals shall be the primary text.

1. Each course participant shall receive copies of the Operation and Maintenance Manual, Training Manuals, and other pertinent material prior to the commencement of all courses.

2. In addition to the copies provided for trainees, the Contractor shall provide the master and two additional copies of all Training Manuals and class materials as reference documentation.

3. Upon completion of each course, Operation and Maintenance Manuals, Training Manuals, and Training Aids shall become the property of the District. Throughout the Contract and warranty periods, it shall be the responsibility of the Contractor to supply the District with any changes and revisions to the Training Manuals and other documentation.

4. The District reserves the right to copy training materials and aids for use in District conducted training courses.

5. The Contractor shall provide all special tools, equipment, training aids, and any other materials required to train course participants. The number of special tools and other training equipment shall be adequate for the number of participants attending each course session (up to 40 in all).

6. The District will provide the Contractor written comments on the Training, Training Manuals and equipment based upon the first sessions. The Contractor shall incorporate the comments and resubmit the documents 60 Days prior to the last training sessions.

G. Videotaping:

1. Provide video training tape(s) covering complete troubleshooting of elevator drive/fault finder system for use by District's Instructors.

2. In addition, the Contractor may utilize prerecorded lectures as supplementary training material. These shall not serve as a replacement for a classroom instructor or as the primary training vehicle. The Contractor shall provide such videotapes to the District for retention and playback by the District's Instructors as reference documentation.

3. The District shall have the right to videotape training courses presented by the Contractor. The District shall also have the right to use these videotapes to train personnel in the future.

H. Final Training Documents:

1. Updated and corrected Training Manuals and attachments as specified.

2. Sets of participant's materials, 30 Days prior to commencement of training. Quantity of materials per class size specified herein.

3. Any models, mockups, simulations, or other material to conduct the training program.

END OF SECTION 14 21 00

SECTION 14 24 00

HYDRAULIC ELEVATORS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Elevator System Description.

B. Design and Operation Requirements.

C. Submittals.

D. Spare Parts.

E. Operation and Maintenance Data.

F. Maintenance Services.

G. Reliability.

H. Permits.

I. Hoistway Construction.

J. Machine Room.

K. Equipment in Hoistway and Machine Room.

L. Hoistway Entrances.

M. Car and Hoistway Doors.

N. Electronic Door Edge Sensor.

O. Car Enclosure.

P. Elevator Floor and Platform.

Q. Electrical Components.

R. Controller.

S. Remote Monitoring System.

T. Signals and Operating Fixtures.

U. Recessed Motion Sensing Unit.

V. Cameras.

W. Signs.

X. Vibration Absorption Mounts.

1.02 RELATED SECTIONS

A. Section 03 61 11, Non-Shrink Grout

B. Section 08 90 00, Louvers

C. Section 09 91 00, Painting

D. Section 09 67 70, Elevator Spray-on Flooring

E. Section 10 40 00, Safety Specialties

F. Section 20 10 13, Common Materials and Methods for Facility Services – Fire Suppression, Plumbing and HVAC

G. Section 20 70 26, Common Materials and Methods for Electrical Systems

H. Section 21 13 13, Wet Pipe Sprinkler Systems

I. Section 26 05 24, Low and Medium Voltage Wires and Cables

J. Section 27 30 01, Telephone Systems

K. Section 28 31 00, Fire Detection and Alarm System

L. Section 28 41 29, Closed Circuit Television Systems

1.03 MEASUREMENT AND PAYMENT

A. General: The elevator will not be measured separately for payment but will be paid for as part of the indicated Contract lump sum price for elevator.

1. Elevator maintenance will be paid as unit price as indicated on the Bid Form.

2. Chargeable repairs will be paid separately for labor and maintenance as indicated on the Bid Form. Labor will be paid as unit price and material will be actual cost plus mark-up as indicated on the Bid Form.

1.04 REFERENCES

The requirements of the prevailing versions of the following standards at time of contract signing shall be met.

A. American National Standards Institute (ANSI):

1. ANSI A117.1	Accessible and Usable Buildings and Facilities
2. ANSI Z97.1	Glazing Materials Used in Buildings, Safety Performance Specifications and Methods of Test

B. American Public Transit Association (APTA):

1. APTA RT-EE-RP-002-03	Heavy Duty Transportation System Elevator Design Guidelines

C. American Society of Mechanical Engineers (ASME):

1. ASME A17.1	Safety Code for Elevators and Escalators
2. ASME A17.2	Guide for Inspection of Elevators, Escalators, and Moving Walks
3. ASME A17.3	Safety Code for Existing Elevators and Escalators includes Requirements for Electric and Hydraulic Elevators and Escalators

D. American Society for Testing and Materials (ASTM):

1. ASTM A36/A36M	Specification for High-Strength Low-Alloy Collumbium-Vanadium Structural Steel
2. ASTM A572FR.50	Specification for Carbon Structural Steel
3. ASTM A53/A53M	Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
4. ASTM A1008/ A1008M	Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable
5. ASTM B3	Specification for Soft or Annealed Copper Wire
6. ASTM B174	Specification for Bunch-Stranded Copper Conductors for Electrical Conductors
7. ASTM B209	Specification for Aluminum and Aluminum-Alloy Sheet and Plate
8. ASTM B211	Specification for Aluminum and Aluminum-Alloy Bar, Rod, and Wire
9. ASTM B221	Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes

10. ASTM B308/B308M	Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles
11. ASTM C864	Specification for Dense Elastomeric Compression Seal Gaskets, Setting Blocks, and Spacers
12. ASTM C1048	Specification for Heat-Strengthened and Fully Tempered Flat Glass
13. ASTM D2240	Test Method for Rubber Property-Durometer Hardness
14. ASTM F36	Test Method for Compressibility and Recovery of Gasket Materials

E. American Welding Society (AWS):

1. AWS D1.1	Structural Welding Code – Steel

F. BART Facilities Standard Drawing AS08, AS09, AS10, AS11, Architectural Elevator Details.

G. District Technical Manual – SCADA System Function Description

H. National Association of Architectural Metal Manufacturers (NAAMM):

1. AMP 503	Finishes for Stainless Steel

I. National Electrical Manufacturers Association (NEMA):

1. NEMA AB 1	Molded Case Circuit Breakers, Molded Case, Switches and Circuit-Breaker Enclosures
2. NEMA PB 1	Panelboards

J. National Elevator Industry, Inc. (NEII):

1. NEII-1	Building Transportation Standards and Guidelines

K. National Fire Protection Association (NFPA):

1. NFPA 70	National Electrical Code
2. NFPA 101	Life Safety Code
3. NFPA 130	Fixed Guideway Transit and Passenger Rail Systems

L. Steel Structures Painting Council (SSPC):

1. SSPC-SP 1	Solvent Cleaning
2. SSPC-SP 3	Power Tool Cleaning
3. SSPC-CS 23.00	Specification for the Application of Thermal Spray Coatings (Metallizing) of Aluminum, Zinc, and Their Alloys and Composites for the Corrosion Protection of Steel

M. Underwriters Laboratories Inc. (UL):

1. UL 1581	Reference Standard for Electrical Wires, Cables, And Flexible Cords

1.05 REGULATORY REQUIREMENTS

A. In addition to the foregoing referenced standards, any regulatory requirements which govern elevator work of these Specifications shall include, but not be limited to, the following codes and regulations:

B. Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities (ADAAG Guidelines) 49 CFR Subtitle A, Part 37, Appendix A.

C. California Code of Regulations (CCR):

1. CCR Title 8, Industrial Relations, Division 1, Chapter 4, Subchapter 6, Elevator Safety Orders

2. CCR Title 24, Part 2, California Building Code (CBC)

3. CCR Title 24, Part 3, California Electrical Code

D. California Occupational Safety and Health Act (CAL/OSHA)

E. In the event of a conflict between codes, regulations, standards or these specifications, the most stringent requirement shall take precedence unless specifically required by the Engineer.

1.06 QUALITY ASSURANCE

A. The Contractor shall be responsible for integrating all elevator, machine room, station agent’s booth and hoistway components to ensure a fully compliant, operable elevator system.

B. General: At the completion of the work, the elevator shall meet the requirements of CCR Title 8, CCR Title 24, Part 2, NEC, ASME A17.1, A17.2, A17.3, and NFPA 101 and 130. Install per manufacturer’s requirements and as specified herein.

C. Comply with AWS D1.1 standards for finished work and for qualifications of welding operators and corrosion protection.

D. The controller wiring shall be carried out in accordance with the minimum requirements of CCR, Title 24, Part 3, California Electrical Code.

1.07 SYSTEM DESCRIPTION

A. Elevator Type: Hydraulic.

B. Load Capacity: 3,500 pounds for elevators with side opening doors and 4,000 pounds for elevators with center opening doors in all stations and parking structures.

C. Speed: 100 feet per minute, with maximum five percent speed variation under any loading condition in either direction.

D. Stops: As indicated.

E. Main Floor: Ground floor, unless otherwise specified in the Contract Specifications.

F. Entrance size:

1. Minimum 42 inches wide by 84 inches high for elevators with side opening doors.

2. Minimum 48 inches wide by 84 inches high for elevators with center opening doors.

3. Entrances shall be sized for emergency evacuation of a horizontally positioned ambulance stretcher 24 inches by 84 inches or per fire department having jurisdiction, whichever is greater.

G. Travel: As indicated and verified in field.

H. Controller: The controller shall be a District Matching Product (DMP) as specified herein (Ref. Appendix A).

I. Machine Room Location: Ground floor machine room as close as possible to hoistway.

J. Car Inside Dimension: Car inside clear dimension shall be a minimum of 92 inches wide and a minimum of 64 inches deep from wall to wall. Minimum height shall be 96 inches.

K. Remote Monitoring System: The Elevator Remote Monitoring System shall interface with the existing BART monitoring system (EERMS). As specified herein.

L. Electronic car door edge sensors: Sensors shall be a Designated Matching Product (DMP) as specified herein (Ref. Appendix A).

M. Car Enclosure: Passenger type.

N. Comply with standards established in the NEII Building Transportation Standards and Guidelines, unless specified otherwise herein.

O. Doors:

1. For elevators rated for 3,500 pounds, car and hoistway doors shall be side opening.

2. For elevators rated for 4,000 pounds, car and hoistway doors shall be center opening.

3. Car and hoistway doors shall be horizontal sliding, single speed, stainless steel with a vision panel in each door.

1.08 DESIGN AND OPERATION REQUIREMENTS

A. Elevator System General Requirements:

1. Elevators shall be designed specifically for the operation, loading and environmental conditions encountered in extensively used, heavy duty rail transit systems and shall have a minimum design life of 20 years. Elevators shall be bored in ground cylinder type, holeless and machine room less (MRL) are not acceptable.

2. Elevators shall operate while exposed to sunlight, rain, airborne dust, and debris.

3. The final assembly of all components shall not pose hazardous conditions to the public or maintenance personnel. Surface irregularities, sharp edges, or protrusions in public or maintenance areas shall not be permitted.

4. Provide convenient and safe equipment access for inspection, cleaning, maintenance, repair, and replacement.

5. All gaps and running openings within regulatory tolerances shall be properly closed by the use of appropriate sealant or another approved means installed in accordance with the manufacturers' instructions.

6. For parts and equipment subject to wear and requiring periodic replacement, the Contractor shall furnish key and seat, nut, screws, or other removable and replaceable type mechanical fasteners. Such replacements shall not diminish original structural integrity. Use of rivets or similar type fasteners requiring physical deformation during field positioning will not be permitted.

7. The elevator equipment shall be quiet and smooth running and shall not exceed the following maximum noise output levels during all phases of operation:

   a. 80 decibels measured in the elevator machine room

   b. 70 decibels measured in the elevator car

   c. 70 decibels measured at the elevator hoistway entrances

8. Fire Protection: Contractor shall provide non-combustible materials for components.

9. Hydraulic Pressure: Hydraulic components shall be factory tested for 500 psi. Maximum operating pressure shall be 400 psi.

10. Maximum reservoir oil temperature shall be 160 degrees Fahrenheit with outdoor temperature of 110 degrees Fahrenheit under continuous elevator use.

B. Seismic Criteria:

1. Installation and equipment designed for static and for seismic conditions shall be provided in accordance with regulatory requirements.

2. Provide hardware necessary to protect motors, controllers, hydraulic reservoirs, and door operators.

3. Seismic design shall be based on the seismic requirements for elevators in ASME A.17.1 and Section 3137 (a) and (b) of the California Code of Regulations in effect in California at the time of Contract signing.

C. Power:

1. The main elevator power shall be 480 Vac, three phase, 60 Hertz. The power shall be supplied from the emergency power panel or bus.

2. As a minimum, three separate 120 Volt circuits shall be provided, one for each of the following loads: elevator car lighting and fan, elevator pit and hoistway lighting and receptacles, and car camera. Any 120 Volt elevator control circuits shall be provided from the elevator controller by means of a step down transformer.

D. Elevator Controller:

1. Refer to Article 2.13, Controller, herein. The controller shall be a field programmable microprocessor based, simplex selective-collective, automatic operation, with closed loop, variable voltage, variable frequency control.

2. Elevator operation shall be by means of pushbuttons in the car, at terminal and intermediate landings, numbered to correspond to landings served, by CALL DEMAND pushbuttons at terminal landings, and by UP and DOWN pushbuttons at intermediate landings.

3. The activation of one or more pushbuttons shall illuminate the pushbuttons and dispatch the nearest car to the designated landings in the order in which the landings are reached by the car, regardless of the order in which the calls were registered. When the car reaches the landing, the illumination of the corresponding pushbutton shall cease.

4. If hall calls are received for the opposite direction of travel, the car shall continue in the same direction until all calls in the initial direction are answered, then the car shall reverse direction to collect call in the opposite direction.

5. If no calls are registered and the car is unoccupied, the car shall either remain at the current landing until further calls are registered or be dispatched to the designated, programmable, home landing and stop without door operation. Timing setting parameters shall be supplied by the Engineer.

6. Special Operations:

    a. Inspection Operation: Inside the car service cabinet within the Car Operating Panel, there shall be an Inspection key-operated switch keyed to EX 514 for normal “run” or “inspection” operation. There shall be three means of initiating car movement for inspection service; at the car top inspection station, inside the controller, and by the hoistway access key switches. Car movements initiated by the car-top inspection station or by the hoistway access key switches shall be at low or full speed and disable the controller inspection switch. The controller shall be equipped with a toggle switch for low or high speed selection. The car will run either up or down by constant pressure on the up or down switches, provided the doors are closed and the safety circuit is made. Releasing the directional button will cause the car to stop immediately. Activating any of the run/stop switches to “stop” position will render the car inoperative. Turning the inspection switch to the “run” position will restore the car to automatic operation.

    b. Independent Service: A key switch keyed to EX 513 shall be provided in the car service cabinet to allow for independent service. The car can be removed from automatic operation and be operated manually. Independent service shall have full control of the starting, stopping, and direction of car travel. The car shall respond to car buttons only. The arrival gongs, hall lanterns, and hall calls shall be inoperative during independent service mode.

    c. Operation Under Fire Conditions: Provide special fire service to comply with the requirements of latest revision of CCR Title 24, Part 2, California Building Code, Chapter 30 for State Fire Marshal (SFM) facilities, ASME A17.1, and local fire codes having jurisdiction. As a minimum, provide the following:

        1) Phase I Fireman’s Service recall, three-position key switch at main (egress floor) keyed to EX 515 level shall be integrated in hall call stations with engraved instructions.

        2) Fire alarm initiating devices shall be installed in machine rooms and each non-open air landing, and hoistways shall be equipped with a wall-mount fire sprinkler mounted at a nominal height of 22 inches above the pit floor. Elevator operation shall be in accordance with applicable codes.

        3) Phase II fire service shall be provided. A three position key-operated switch keyed to EX 515 shall be mounted in the Car Operating Panel and operate accordance with applicable codes.

4) All initiating fire alarm signals shall be routed to the main fire alarm panel through four fire alarm control relays with the following signals:

   a) Primary Recall

   b) Secondary Recall

   c) Shunt Trip

   d) Fire Fighter's Hat

   The relays shall be installed inside a read NEMA 4 box within three feet of the elevator controller. The station fire alarm panel shall initiate the appropriate signals to the elevator controller in accordance with applicable codes.

5) Spot-type photoelectric smoke or heat detectors (depending upon the hazard's environment) will be provided adjacent to the station and parking structure elevator openings (located in accordance with the relevant requirements within the code). With the exception of the detector located adjacent to the elevator opening on the primary elevator recall floor, operation of any of these detectors will initiate the elevator capture and recall functions from the FACU to recall the elevator to the designated primary floor. Operation of the detector adjacent to the elevator opening on the primary elevator recall floor will initiate the elevator capture and recall functions from the FACU to recall the elevator to the designated secondary floor. These devices will communicate with, and be powered from, the FACU. Operation of a device will cause an alarm signal to be transmitted to the FACU; will cause operation of all the station's occupant notification appliances; will cause transmission of an alarm signal to BART's monitoring location; and will cause the recall operations identified above.

6) Operation under Loss of Power: The controller shall be equipped with a battery-powered lowering device to allow automatic lowering of elevator to lowest landing and opening of the doors. Elevator will then remain out of service.

7) Operation under Earthquake Conditions: Provide seismic operation in accordance with the requirement of CCR Title 8. Each station shall be equipped with a seismic device in the Train Control Room or Auxiliary Communication Room within the station. Provide the wiring, raceway and elevator control circuitry for the seismic control circuit.

7. The controller shall be equipped to provide remote control and indication signals to the Station Agents Booth as specified in Article 2.15, Signals and Operating Fixtures.

   a. Car moving up (indication).

   b. Car moving down (indication).

   c. Concourse (control and indication, hall call activation).

   d. Street or Platform, one for each landing as required (control and indication, hall call activation).

e. Car Occupied (indication).

f. Alarm (indication).

g. Elevator shutdown (control and indication).

8. The elevator controller shall be equipped with a toggle switch to disable the door operator power while still moving the car under independent service from the controller.

9. The controller shall be equipped to provide the indication signals to the EERMS as specified in Article 2.14, Remote Monitoring System.

10. The system shall utilize an automatic two-way leveling device to control the leveling of the car. Leveling range plus or minus 1/4 inch under any loading conditions. Over travel and under travel shall be compensated for and the car brought level to the landing sill.

11. All options or parameters shall be field programmable without need for external devices. Programmable settings shall be stored in non-volatile memory.

12. The automatic leveling zone shall not extend more than 12 inches above or below the landing level, nor shall the doors begin to open until the car is within six inches of the landing. In addition, the inner landing zone shall not extend more than three inches above or below the landing. The car shall not move if it stops outside the inner leveling zone unless the doors are fully closed and locked.

E. Elevator Car and Hoistway Door Operation:

1. Hoistway doors and car doors shall:

a. Open automatically and simultaneously when the car arrives at the destination landing.

b. Be equipped for readily and independently adjustable door hold open times when car stops for a car or hall call. Main floor door hold times shall be adjustable independently of other floors.

c. Close after hold open time interval has elapsed and no obstruction has been detected, or when the car is called or dispatched to another landing, or when either the car door close button or a car call is pushed.

2. Activation of the door close button in the car shall cancel door open timer and close the doors provided there is no obstruction.

3. All closing times shall be adjustable from five seconds to 30 seconds without exceeding closing force specified herein.

4. Door Dwell Times: Door dwell times shall be fully adjustable with initial settings as follows:

    a. Hall Call: 20 seconds

    b. Car Call: 10 seconds

    c. Reopening: 20 seconds

    d. Nudging: 16 seconds

F. Access Requirements: Signals and fixtures shall be as indicated on Contract Drawings and specified herein. Components may be rearranged upon Engineer's written approval. Location and arrangement of fixtures shall comply with Accessibility requirements of the latest CCR Title 24, Part 2, California Building Code and ASME A17.1.

1.09 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit complete shop drawings and data including installation details and printed manufacturer's specifications for elevator car, control system, hydraulic power pack, valves, jack assembly, emergency and safety system, door assembly, door operators, and others as required. Text font type and size shall be uniform throughout the set of shop drawings, not less than eight point font. Shop drawings and details shall include, but not be limited to the following:

1. Car interior panel, reflected ceiling, flooring, and base material specification.

2. Platform assembly.

3. Signal Fixtures: Control buttons and lamps.

4. Hoistway Entrance: Hoistway and car doors, sills and sill supports for hoistway and car as indicated, door operators, drive and clutches.

5. Elevator doors and door operator. Provide components, layout detail complete with fastenings, etc. Include weight of doors.

6. Weights of car doors.

7. Indicate direction of stainless steel directional grain.

8. Machine room layout.

9. Hoistway layouts, to include clearances, guide rails and buffers.

10. Paint schedule.

11. Wiring diagrams.

12. Complete power, control, and indication schematic diagrams. Provide wiring list and connection diagrams. Diagram shall include interface connections to the external system circuits, such as fire alarm, telephone, CCTV, EERMS, and station agent's booth. Provide the installation wiring lists for all devices, detailing each individual cable and wire number, color and terminal designation per elevator, used during the installation.

13. Assignments of all processor input/output conductors including position indicating system.

14. Traveling cables: Provide details of the traveling cable attachment on both ends.

15. Hydraulic pumping system: Pump, valves, motor, and piping.

16. Hydraulic ram system: Cylinder, casing, packing oil seal, jack oil collection trough, and oil scavenger system. Provide detail of ram to platen plate.

17. Motion Sensor and elevator camera.

18. Limit switches and mounting detail.

19. Submit detail for oil collection tank frame support assembly.

C. Engineering Data Including Design Calculations:

1. Submit separate data sheets for machine room heat release calculations based on 30 trips per hour for two hours, power requirements, conduit fill, and car guide shoes and hydraulic system. Power requirements shall indicate maximum and average power demands, and requirements for emergency power operation.

2. Submit structural design calculations for car assemblies, car guide rails and supports, ram and cylinder. Design calculations shall be performed and sealed by a Civil or Structural Engineer currently registered in the State of California.

3. Submit seismic calculations for oil collection tank frame support assembly.

D. Samples: Provide samples of materials and finishes exposed to public view. Include the following items:

1. Car finish floor, 12 by 12 inch panel.

2. Car finish wall and ceiling surfaces, 12 by 12 inch panel.

3. Buttons, switches and lamps.

4. All Braille signs, full size.

5. Car and hall door, Astragal material.

E. Product Data:

1. Submit manufacturers' design data and material specifications for all parts and equipment. Specifications shall include test methods required to verify compliance with specifications.

2. Product data for lubricants, sealers, paints, solvents and potentially hazardous substances shall be submitted for Engineer's review. The Contractor shall submit the necessary Material Safety Data Sheets (MSDS).

F. Submit a Test Program for approval with a test schedule and test procedure format for every representative type of test indicated in Article 3.03, Field Quality Control.

G. Test Reports: The Contractor shall submit a complete report describing the detailed results of each regulatory test.

H. Maintenance Program: The Contractor shall submit routine preventive maintenance program, showing functions to be performed and their scheduled frequency.

1.10 SPARE PARTS

A. General: Spare Parts shall be provided in accordance with Section 01 78 44, Spare Parts and Maintenance Materials, augmented by the following provisions.

B. Spare parts shall become the District's property and shall not be used by the Contractor for maintenance.

C. A "set" is the number of parts required for one fully operable elevator.

D. Recommended Spare Parts List: Submit for approval a List of recommended spare parts necessary to support maintenance for a period of two years. The Engineer will review the List, assign a District Stock Number to each item and return the List to the Contractor. The Contractor shall incorporate the District's Stock Number and resubmit the List, together with two additional sets of bar code labels to the District.

E. Minimum Required Spare Parts List. The Contractor shall provide, at a minimum, the following spare parts for each elevator installed:

1. Controller components as recommend by manufacturer: One set of each printed circuit board, relays, and fuses as approved by the Engineer.

2. Car and hall buttons and lamps, arrival gong lamps: Two sets of each type.

3. Car fluorescent lamps: Four each.

4. Limit switches: Two each.

5. Rollers for roller guides: Two of each size.

6. Gibs: Two of each size used.

7. Packing gland.

8. Car and hall door Astragal material: Three sets.

9. Complete Pana 40 door edge complete assembly with controller and cables.

10. Door clutch assembly.

11. Hall door lock assembly.

F. Delivery: Notify the Engineer in writing 72 hours prior to any delivery. The notification shall identify the specific parts to be delivered. All spare parts shall be delivered no later than 30 Days prior to the final acceptance of the elevator.

1.11 OPERATION AND MAINTENANCE DATA

A. Submit the following in accordance with Section 01 78 23, Operation and Maintenance Data, prior to acceptance.

1. Operation and maintenance manuals may consist of off-the-shelf manuals as described in Section 01 78 23, Operation and Maintenance Data, Article 1.06D. However, the manual shall also include a separate chapter or volume to identify the unique items and installations that are unique specifically to this contract, which is not covered, in the off-the-shelf manuals. This chapter shall meet the requirements of system manuals as specified in Section 01 78 23, Operation and Maintenance Data, excluding articles 1.12C, 1.12D, and 1.12E. This chapter and all its contents, and all wiring diagrams shall be provided in electronic format as specified 01 78 23, Operation and Maintenance Data, Article 1.11.

2. Wiring Diagrams: One set, half size or 11 by 17 inch, whichever is larger, shall be laminated and stored in the machine room, and full sized sets delivered to the Engineer. Wiring diagrams shall be “As Built”, specific for this installation, and reference identification on drawings shall match points identified on terminals of controllers (wire lists are not acceptable). Wiring diagrams shall include interface and schematic diagrams. Wiring Diagrams shall include the Elevator Communication Interface cabinet.

3. Maintenance Tools and Software Manuals: Furnish maintenance tools and supporting software documentation required for the complete maintenance of the entire system including diagnostics and adjustment. Maintenance tools may be hand held or built into control system and shall be neither of the type requiring recharging or reprogramming nor of the automatic destruct type. The tool and supporting software may be programmed to operate only with this project’s identification serial number.

1.12 MAINTENANCE SERVICES

A. Maintenance Program: Within 90 Days after Notice to Proceed (NTP), and prior to installation, Contractor shall submit a detailed maintenance program, showing functions to be performed and their schedule. The maintenance program shall include preventative maintenance, trouble call service, and emergency repair service during the Maintenance Period. The maintenance program shall include all work and materials needed to keep the equipment in perfect operating condition. Contractor shall coordinate and perform maintenance in a manner to result in minimum inconvenience to the public.

B. Maintenance Period:

1. Contractor shall perform maintenance and any repairs on the elevator due to equipment failure for a period of 12 months after Substantial Completion and the unit is open for public use. During the Maintenance Period, Contractor shall provide complete preventative and corrective maintenance on all components and assemblies of the elevator. At the end of the 12 months Maintenance Period, the District may extend the maintenance period by an additional two (2) years. If the District exercises this option, the Contractor will be compensated in accordance with the corresponding bid schedule line item. The District reserves the right to terminate the Maintenance Period at any time, upon giving 30 days' notice to the Contractor. Contractor will not be relieved of maintenance until Relief from Maintenance is granted by the District.

2. Maintenance service shall not be subcontracted and shall be performed by or supervised by the Contractor's qualified CCCM personnel.

3. Maintenance shall include all labor and materials needed to achieve and maintain minimum 96 percent reliability for the equipment. Contractor shall coordinate and perform maintenance in a manner to result in minimum inconvenience to the public.

4. At the completion of the Maintenance Period, the equipment shall receive a final inspection performed jointly be the Contractor and the District representative. All discrepancies identified shall be corrected at no additional cost to the District.

5. The maintenance service will not be required to cover adjustments, repairs, or replacement parts due to misuse, abuse, or vandalism.

6. The Contractor shall maintain local inventory of all wearing parts of the elevator system. Only genuine OEM parts and supplies used in the manufacture and installation of the original equipment shall be provided.

7. Contractor shall obtain written approval from the BART administrator prior to replacing parts.

8. Contractor shall provide and maintain up-to-date complete list of personnel who access the District assets. The list shall include names and 24 hour contact information, including telephone numbers.

C. Trouble Calls During Maintenance Period

1. For any trouble calls the District will notify the Contractor of the incident. The Contractor shall be on site within four hours. The Contractor shall notify the designated BART Elevator/Escalator Maintenance representative upon arrival to the site, and check out upon completion of the trouble call. BART personnel may observe the repairs or adjustments made by the Contractor's personnel.

D. Elevator Access

1. For routine maintenance, the Contractor shall request access to the elevator and coordinate access with the BART Elevator/Escalator Maintenance Department representative.

2. When routine maintenance is being performed, the Contractor shall be prepared to return the elevator to service upon request by a patron if it would take the Contractor 15 minutes or less to do so. If the Contractor cannot return the elevator to service is 15 minutes or less, then the Contractor shall assist the patron in contacting the Station Agent for assistance.

E. Work Hours for Maintenance

1. Routine maintenance, non-urgent repairs, and warranty work shall be performed on no more than one elevator at a time at a station. Routine maintenance shall not be performed during revenue peak hours. Routine maintenance may also be performed during non-revenue hours. Refer to the Contract Specifications for a definition of revenue peak hours for the station.

2. Repairs required to return equipment to service shall be accomplished as soon as possible during revenue and non-revenue hours.

F. Inspection during Maintenance Period

1. Contractor shall perform systematic inspection of each elevator system every two weeks and perform adjustment and lubrication of elevator equipment when required as recommended by the manufacturer. Replace defective parts with new parts of same manufacture as required.

2. There will be an annual permit inspection schedule by and at the expense of the District.

3. BART will monitor Contractor's work by whatever means are deemed necessary, including employing others to inspect and/or test the equipment condition and the maintenance work quality.

G. Elevator Shutdowns

1. Should an elevator become inoperative, the Contractor shall attend to the elevator within four hours of notification of such incident except if the incident occurs after 8:00 PM, the service representative shall be on-site no later than 7:30 AM the following Day. This schedule shall apply seven days per week, 52 weeks per year. The elevator shall be returned to service as quickly as possible.

2. Should there be a failure to comply with above time requirements, a penalty of $500 shall be assessed for each hour delay.

H. Final Service and Inspection

1. Two weeks before expiration of the Maintenance Period, the equipment shall be lubricated, fully serviced, adjusted to the standards designated herein and safety devices and emergency service operation shall be checked. The Engineer will make a complete inspection. All deficiencies shall be corrected. Any deficiencies not corrected shall result in the extension of the maintenance services until the deficiencies are corrected at no additional cost to the District.

I. Contractor will not be responsible for cleaning and repair of elevator car walls and hoistway entrances, except if service required is due to detective materials or improper installation. Service personnel shall clean oil and grease residue from maintenance or repair.

J. The Contractor’s technicians responding to trouble calls or per forming Preventive Maintenance shall contact the designated BART Elevator/Escalator Maintenance representative and provide the following information: worker’s name, date, arrival time, total time spent on site, parts inspected, adjustments made, parts replaced, and detailed description of the work done.

K. Keep a work log on each elevator with the following information: Worker’s name, date, time arrived, total time spent back in service time, parts inspected, adjustments and work done, and parts replaced. Every visit, regardless of purpose, shall be recorded in the log. The work logs will be regularly reviewed by the Engineer.

L. Chargeable Repairs: Contractor will not be responsible for the cost associated with trouble calls that are due to misuse or accidents, or are otherwise not caused by Contractor. Calls which result in adjustment of safety devices not accessible to the public will not be reimbursed. Contractor shall submit all documentation necessary to prove that a particular trouble call should be a Chargeable Repair. Contractor shall submit all documentation necessary to justify the direct costs incurred for chargeable repairs and detail charges in accordance with the schedule of service prices submitted and approved by the Engineer prior to the start of the maintenance period.

1.13 RELIABILITY

A. Definitions:

1. Break-in Period: The initial period of operation of the elevator. There shall be only one break-in period for the elevator, regardless of maintenance or modification or other work done on the elevator before, during, or after the break-in period.

2. Failure: An incident which is corrected by replacing a part, resetting the unit, or making an adjustment. Exceptions to failure are conditions of misuse, vandalism, accidents, or negligence not caused by the Contractor.

3. Incident: An incident is any elevator stoppage, regardless of cause.

4. Pattern Failures: The occurrence of multiple independent failures of the same primary replaceable item or adjustment in identical or equivalent applications.

5. Reliability Demonstration Test (RDT): A test to determine a reliability-associated parameter, such as available operating time, within defined statistical risks or with a specific statistical confidence.

B. Requirements:

1. Break-in Period shall begin after the installer has satisfactorily completed the elevator installation, obtained by State operating permits and the Engineer has performed and approved substantial inspection of the elevator. The elevator shall be barricaded and operated continuously under no load condition for a minimum of 48 hours. Upon a continuous, 48-hour operation without incident, the barricades may be removed and the escalator may be put into service to be used by the public.

2. After the Break-in Period, the Reliability Demonstration Test (RDT) shall begin. The escalator shall operate up to full load under normal modes of operation in either direction and be able to provide minimum 96 percent reliability as determined by the following formula:

Percent Reliability = T/A

T = Actual aggregate operating time for the elevator. Downtime for scheduled preventive maintenance and incidents, which are not failures, shall not be deducted from the aggregate operation time.

A = Aggregate revenue operating time of the respective BART station, nominally 20 hours per day.

3. Contractor shall take corrective action to eliminate pattern failures, regardless of total operating time accumulated. The Contractor shall notify the District's Engineer or designated Elevator/Escalator Maintenance representative that an elevator undergoing corrective maintenance is ready to be returned to service to ensure appropriate time tracking for the purpose of accurately tracking the reliability percentage by using the formula above. Failure by the Contractor to report "returned to service" will result in lower reliability performance and will remain the responsibility of the Contractor.

C. The Contractor shall:

1. Collect the data and document the results of the RDT, perform all calculations, and issue the results.

2. Review failure incident reports to ensure that only pertinent failures are included in the test results.

3. Review the data with the District at interim stages of the RDT and at the final stage, prior to issuing the results.

D. If the District determines that the RDT has fallen below the 96 percent goal for any consecutive 30 Day period, the Maintenance fee due to the Contractor for that 30 Day period shall be reduced by the following formula:

A = MF * Percent Reliability

A = Amount due to Contractor

MF = Monthly Maintenance Fee for one elevator

E. Prepare and submit reliability and maintainability reports.

1.14 PERMITS

A. Refer to General Conditions Article 7.4, Permits and Licenses, for the Contractor's responsibility to obtain and pay for any and all necessary permits including permit to complete. Contractor shall submit any required drawings and design calculations to State of California Elevator Division and a copy to the Engineer. The Contractor shall pay for all Elevator Division's inspections as applicable, including those occurring during the Maintenance Period.

PART 2 – PRODUCTS

2.01 GENERAL

A. The general system description for the elevators, which include elevator make and type, number of stops, car and hoistway door and operators configuration and design, controller type, dimension of car floor and enclosure shall be as indicated in Articles 1.07, System Description and 1.08, Design and Operation Requirements.

B. Weatherproofing: Metal surfaces shall be hot-dipped galvanized, except nonferrous metals and stainless steel, or as indicated. Machined and operational areas shall be protected from corrosion by applying a rust preventative compound, oil or grease. Refer to Article 2.12, Electrical Components, for related requirements.

2.02 MATERIALS

A. Sheet Steel: ASTM A1008/A1008M, uncoated, pickled.

B. Fasteners: Hardware, including nuts, bolts, washers, screws, and other fasteners shall be stainless steel throughout, including any concrete anchors. Provide all fasteners necessary for proper erection and assembly of work. Fasteners and hardware for hangers and tracks shall be Type 316 stainless steel.

C. Stainless Steel: Type 316, unless Type 316 does not exist for a particular item. Type 304 may be used only as approved by the Engineer.

D. Structural Steel: ASTM A572 Grade 50 or ASTM A36 for car platform and sling. Hoistway entrances struts, headers, etc. shall be galvanized.

E. Aluminum: ASTM B209, B211, B221, and B308/B308M. ANSI 6061 or alloy and temper best suited for anodizing finish specified.

F. Engraving on stainless steel panels:

1. Size: As indicated.

2. Color: Backfill with black epoxy paint, except text and symbols for fire or emergency service shall be red epoxy paint.

3. Typeface: Univers 65 or Helvetica.

G. Grout: Non-staining, non-shrink as specified in Section 03 61 11, Non-Shrink Grout, and appropriate to application:

2.03 FINISHES

A. Stainless Steel Grade 316, Exposed to View by Public: Satin, vertical directional grain or as indicated, NAAMM AMP No. 4 finish. Sanding medium shall not deposit particles in the grain that are capable of rusting. Provide NAAM AMP No. 4 finish on stainless steel not exposed to view when indicated.

B. New cast or machined non-stainless metal parts, including platform hydraulic reservoirs and framing, drip pans, hoist machine, platform, pit buffers, non-stainless steel, sub floor, and similar parts which are not exposed to view and not specified to be galvanized shall be cleaned, primed and painted as follows:

1. After fabrication and immediately before shop painting, ferrous metalwork shall be power-tool cleaned in accordance with SSPC-SP-3 to remove mill scale, rust, grease, oil, and any other foreign matter. Welds shall be thoroughly wire brushed.

2. After power-tool cleaning and just before shop painting, ferrous metalwork shall be washed with solvent to remove dust and residue in accordance with SSPC-SP1. Metalwork shall be coated with 100 percent Zinc thermal spray per AWS C2.23M/C2.23, NACE No. 12, SSPC-CS23.00.

3. Immediately after cleaning and solvent washing, ferrous metalwork shall be shop painted with one coat of corrosion resistive metal primer and finish coat of gray enamel paint.

C. Concealed structural members shall have prime coat specified herein or be galvanized.

D. Entire hoistway, except pit area, shall be painted white with Semi-Gloss Finish Paint System in accordance with Section 09 91 00, Painting, as applicable to substrate. Raceway and other pre-finished items shall be painted to match.

E. If not otherwise indicated on the Contract Drawings, Machine Room floor shall be painted gray with the Epoxy Floor Paint System specified in Section 09 91 00, Painting.

F. If not otherwise indicated on the Contract Drawings, the Machine Room walls and ceiling shall be painted white with Semi-Gloss Finish Paint System in accordance with Section 09 91 00, Painting, as applicable to substrate.

2.04 HOISTWAY CONSTRUCTION

A. Hoistway shall be constructed of non-combustible material with the fire rating required to meet the applicable Code requirements of the building but shall be a minimum two-hour rated construction. Protrusions into hoistway equal to or exceeding four inches shall be beveled 75 degrees or greater to horizontal. Clearance from car to hoistway shall be one inch or greater.

B. The top of the hoistway shall be enclosed and watertight.

C. The minimum vertical distance in the refuge area between the top of car enclosure and the overhead structure or other obstruction shall be not less than 60 inches when the car has reached its maximum upward movement.

D. Hoistway shall be vented with a louver of a minimum three square feet as indicated on the Contract Drawings. Refer to Section 08 90 00, Louvers.

E. Hoistway shall have a floor drain or sump with drain as indicated on the Contract Drawings. Drains shall be connected to the Station’s industrial waste line or as indicated on the Contract Drawings. Sump covers shall be of galvanized grating that is mounted flush with the floor. Grating shall be removable and have openings not to exceed one inch.

F. Install fire-suppression sprinkler in hoistway pit in accordance with Section 21 13 13, Wet-Pipe Sprinkler System. Sprinkler head shall be located between 20-23 inches above the pit floor.

G. Install no pipes, conduits, or wiring in hoistway or machine room, except those used in connection with the direct operation of the elevator.

2.05 MACHINE ROOMS

A. Machine rooms and auxiliary machine spaces shall be sized to accommodate the elevator and related equipment with ample space for maintenance and replacement of all equipment located in the machine room. The machine room floor area shall be at least 150 percent of the square footage required by NEII-1 or as indicated on the Contract Drawings.

B. Machine rooms shall be equipped with smoke detectors as specified in Section 28 31 00, Fire Detection and Alarm System. Detectors shall interface with the elevator controller via the main fire alarm panel.

C. Refer to the Contract Drawings for ventilation or air conditioning provisions.

D. Refer to Section 10 40 00, Safety Specialties. Provide a rechargeable ten-pound, 4A-60B:C fire extinguisher with metal wall-mounting bracket.

E. Machine room shall not contain any equipment or items not related to the operation of the elevator.

F. The lighting branch circuit for the machine room should be separate from the receptacles. These circuits shall supply no other load.

2.06 EQUIPMENT IN HOISTWAY AND MACHINE ROOM

A. Casings, Cylinder and Plunger:

1. Outer Casing: Provide outer well Sch 20 steel pipe casing protected from corrosion with 20 mil. mastic coating. The steel casing shall be sealed to prevent water intrusion. Bottom may be sealed with a steel cap or with minimum 24 inch grout plug, as long as the casing will remain water free for the design life. Provide inner polyvinyl chloride (PVC) containment casing and cylinder. Diameter of inner casing shall be at least six inches larger than outsider diameter of wrapped cylinder pipe. PVC casing shall be schedule 80 and rated for minimum 100 pounds per square inch. PVC joints shall be sealed and watertight. Bottom shall be sealed with PVC end cap. Inner casing shall extend above pit floor for snug fit against pit channels.

2. Cylinder: Cylinder shall be steel pipe, factory tested to 500 psi without evidence of failure. Cylinder shall be of one-piece construction or, if required due to length, threaded joint coupling may be used. Cylinder shall be cleaned in accordance with SSPC SP3. The cylinder shall be protected with a minimum of 20 mils of epoxy and a double layer of self-adhesive black polyvinyl chloride tape. Epoxy shall be applied in coats. Tape shall be applied with a minimum of 50 percent overlap for a total thickness of 40 mils. Wrapping shall be applied in the shop.

3. The cylinder shall have a safety bulkhead with orifice sized for the elevator descent of 5-15 feet/per minute in case the cylinder bottom fails. Weld of the safety head shall be minimum one inch from the bottom of the cylinder.

4. Cylinder shall be inspected on site by the Engineer prior to installation.

5. Plunger: Seamless steel pipe or tubing, made from ASTM A53, grade B steel turned and polished, maximum 0.010 inch out of round, and maximum 1/16 inch off straight line. Finish plunger surface to 12 mils or finer. Telescoping plungers or rams are not allowed. Sections shall be threaded and field welded.

6. Packing: Provide “unit” type packing to prevent oil leakage at oil drip ring.

7. Elevator pit ladder shall meet Cal/OSHA requirements.

B. Hydraulic Piping: Hydraulic Piping for elevators refer to Contract Specification Section 20 10 13, Common Materials and Methods for Facility Services, Fire Suppression, Plumbing, and HVAC. The hydraulic piping provided shall comply with the following:

1. Piping only shall be used for hydraulic lines.

2. Provide a sound isolating coupling in oil line between jack and pumping plant.

3. Support piping using vibration isolating closed spring hanger with one-inch-thick acoustic isolator.

4. Provide PVC or polyethylene casing for hydraulic lines between hoistway and hydraulic pumping unit. Casing wall thickness shall be 0.125 inches or greater.

5. Piping shall be sized to limit hydraulic oil velocity to 12 feet per second or less.

C. Mainline strainer: Provide self-cleaning type, 40-mesh element, rated 500 pounds per square inch, minimum.

D. Pit Valves: Pit valves for isolating the cylinder and pumping unit shall be provided as approved by the Engineer with a pressure type, line rupture safety valve to shut off oil between cylinder head and pit valve. Activation of safety valve shall not void operation of lowering valve.

E. Guide rails: Contractor shall provide minimum 18.50 pounds/per foot for the main guide rails and necessary bracketing/supports.

1. The guide rails shall be accurately machined elevator industry standard “T” section guide rails with tongue and grooved joints for the car, weighing not less than that specified in the ASME A17.1.

2. Machined splice plates shall be used to form the rail joints. Each splice plate shall be minimum one and one half inch thick located so it will not interfere with the brackets and clips and not be within 24 inches of any car guide rollers when car is stopped at any landing.

3. Extend rails to the overhead as close to the hoistway ceiling as set forth in ASME A17.1 Section 2.23.8. The maximum allowable deflection of the guide rail shall be 0.50 inch. A structural galvanized structural steel channel mounted to pit floor shall support the guide rails and buffers.

4. Guide rail sections shall not be welded together or welded to mounting brackets.

5. The maximum lateral deflection of elevator guide rails shall be 0.5 inches.

6. The bottom three feet of the guide rails from the pit floor and brackets shall be painted with anti-corrosive paint or epoxy.

F. Guide Rail Rollers shall be of the heavy duty roller type guides that are rated for a minimum of 10,000 pounds. Each roller guide shall consist of, as a minimum, a set of three sound reducing neoprene wheels, with a minimum of six inch diameter and with precision type ball bearings that are held in contact with the rail surfaces by means of adjustable spring loaded devices. Roller guides shall run on dry unlubricated guide rails. Top of car shall be fitted with guards. Roller guides shall be securely bolted to the car frame at top and bottom with stainless steel fasteners and shall be properly aligned to be plumb in respect to the rail surface. Roller guides shall provide smooth and quiet elevator operation. Balance car to ensure equal roller guide pressure will not to exceed manufacturer's recommendations. Nominal roller diameters shall be six inches. Sliding guide shoes may be permitted as approved by the Engineer.

G. Buffers: Buffers shall be of the spring type, specifically designed for elevator applications installed in pairs and sized per code requirements. Buffers shall be supported by a galvanized structural steel channel that is mounted to pit floor.

H. Emergency Stop Switches: Provide emergency stop switches in hoistway pit and auxiliary machine spaces and located as required by State codes. Stop switches shall be heavy-duty watertight, red-colored, mushroom-type push/pull switch.

I. Hoistway Limits: Provide terminal and directional limit switches, access limit switches and final limit switches, as required by the Controller manufacturer. Limit switches shall be heavy duty with NEMA 4 or 4X housings and heavy-duty mountings, fully adjustable plus/minus six inch minimum.

J. Hydraulic Oil Scavenger System: Provide a trough around the hydraulic cylinder packing gland assembly to collect any oil leakage. The oil-scavenging trough shall be equipped with a minimum three-eighths inch flexible transparent tubing. Tubing shall be suitable for oil use and have proper temperature rating. Contractor shall furnish and install an oil scavenging system at each elevator. The oil scavenger system shall collect all surplus oil from jack assembly and transfer surplus oil to a collection tank in the elevator machine room via an oil return pump. Each elevator shall have a dedicated collection tank in the elevator machine room.

1. Hydraulic Oil Return (Scavenger) Sump Pump and Transfer Tank: In the pit, provide electrically operated sealed-submersible scavenger pump, of approximately three gallons per hour, in waste oil transfer tank (approximately three gallon capacity) and float activated or other automatic means to pump oil to

a 15 gallon oil collection tank, located in the machine room. See Section 20 10 13, Common Materials and Methods for Facility Services, Fire Suppression, Plumbing and HVAC, for oil return piping requirements. A flood control shall be included at all locations. A check valve shall be provided in the oil return line to prevent oil from flowing back into the transfer tank. The waste oil transfer tank shall be secured such that it will not be dislodged by water in the pit.

2. Provide a translucent or transparent PVC oil collection tank for oil scavenger system, which is compatible with hydraulic oil, of approximate 15-gallon capacity equipped with heavy duty gate valve type draining capability. Install in a convenient location, in accordance with the approved shop drawings, elevated at least two feet above the machine room floor. Tank frame support assembly shall be galvanized and anchored with stainless steel anchors. The tank shall be equipped with a hi-level switch with a Normally Closed (N.C.) dry contact to be used for generating an alarm condition to the Remote Monitoring System. Provide the conduits and wiring to the remote monitor unit located in the elevator machinery room.

K. Hydraulic Elevator Pumping Plant: Provide the complete hydraulic pumping assembly in accordance with the following:

1. General: The hydraulic pumping assembly shall be self-contained unit with sound reducing cabinet and sound isolated base. Provide secondary containment per CCR Title 24.

2. Hydraulic Pump:

   a. Hydraulic pump shall be specially designed and manufactured for hydraulic elevator service, positive displacement type, designed for steady discharge with minimum pulsation, and smooth and quiet operation. Output of pump shall not vary more than 20 percent between no load and full load in the elevator car.

   b. Submersible elevator hydraulic oil pump shall be minimum speed 1800 revolutions per minute, rated for minimum pressure of 400 pounds per square inch. Provide manual tank shut-off valve to allow replacement of pump without draining reservoir. The pump motor unit shall be installed with fasteners to enable removal of assembly without draining the tank, and all fasteners shall be accessible while tank is filled. Pump motor shall be center mounted.

3. Tank: The tank shall have a V-shaped bottom and capacity equal to plunger displacement plus 25 percent. Provide strainers, oil level gauge with a float switch, and device to maintain uniform oil temperature. Provide a tank cover of matching material equipped with a wire mesh screen and hinged access cover for adding oil to the tank. The access shall be minimum six by six inch with a one-inch deep recess with 50 mesh screen. Provide a minimum three-fourths inch gate valve at the lowest point of the tank accessible for drainage into a five gallon container. The tank shall be equipped with a thermostat, forced cooler and tank heater sized to maintain oil temperature between 90 degrees Fahrenheit and 160 degrees Fahrenheit. Tank assembly shall be mounted on sound isolation pads.

4. Valves: Hydraulic control valve shall be integral (monobloc) type. Provide individual type valves with monobloc type by Maxton, ECCO, or equal. Provide manual lowering valve accessible to maintenance personnel without removing pumping plant enclosure panels. Valves shall be installed with grooved couplings so that removal, repair and adjustments can be performed without dismantling any piping. Provide piping and electrical wiring to controller and hoistway to ensure proper elevator operation. Including down speed regulation to maintain constant down speed regardless of load.

5. Pump Motor: Provide a submersible type pump/motor assembly. Electric motor shall be 480 Vac, 3 phase that is specifically designed for hydraulic elevator service, standard manufacture, and duty rating in accordance with required speeds and loads, rated for minimum of 120 starts per hour. Motor shall be capable of operating at plus or minus 10 percent of normal feeder voltage and plus or minus three percent of feeder frequency without damage or interruption of elevator service. Minimum speed 1800 rpm. Provide heavy-duty motor, continuous rated, Class F or Class H insulation. Motor shall be provided with an internal self-resetting thermal overload, integrated with controller safety circuit.

6. Muffler: Blowout proof type between pumping plant and cylinder.

7. Hydraulic Fluid: Provide non-toxic anti-wear, viscosity grade ISO VG-32 vegetable-based fluid readily biodegradable ISAE viscosity index of 200 or higher.

8. Contractor shall provide a low-level switch for the hydraulic unit oil reservoir. The low-level switch shall have a Normally Closed (N.C.) dry contact and shall be used in conjunction with the remote monitoring system. Provide the conduits and wiring to the remote monitor unit located in the elevator machinery room. Signal shall enable the low oil operation at the controller.

L. Hydraulic Reservoir and Valve: Hydraulic control unit in a single housing, including:

1. High pressure relief valve, externally adjustable, capable of bypassing total oil flow without increasing back pressure in excess of 10 percent over the pressure required to barely open the valve.

2. Check valve shall be designed to close quietly, with no detectable reverse flow.

3. Automatic unloading of up start and up stop valve, externally fully adjustable, designed to bypass oil flow during start and stop of the elevator car motor assembly. Valve shall close slowly, gradually diverting oil to or from the jack unit, providing smooth up starts transition and up stops with soft stop feature.

4. Lowering valve and leveling valve shall be externally fully adjustable for drop-away speed, lowering speed, leveling speed, and stopping speed for smooth down starts transition and stops. The leveling valve shall be designed to level the car to the landing within one-fourth inch in the direction the car is moving.

5. Assembly shall be arranged so that adjustments can be made without removal of the assembly from the oil line or any other equipment.

6. Provide two quick-disconnect fittings on the hydraulic control unit for testing purposes, one to measure the high pressure portion and one to measure the static pressure. Fittings shall be compatible Aeroquip No. FD45-1002-02-02 (male) or equal. Provide a minimum three-inch diameter liquid filled pressure gauge with a maximum scale of 600 psi and with a matching female fitting compatible with Aeroquip FD45-1003-02-02 or equal.

M. Ceiling height in the machinery room shall be a minimum of nine feet above finished floor.

2.07 HOISTWAY ENTRANCES AT ALL LEVELS

A. General: Fabricate finish work smooth with flush surfaces and free from warps dents, scratches and buckles.

B. Hoistway doors shall include door unit frame, flush sills, strut angles, headers, hanger covers, fascia plates, toe guards, dust covers, and required hardware. Exposed surfaces shall be stainless steel. All structural steel shall be galvanized. All fasteners shall be Type 316 stainless steel. Refer to Article 2.08, Car and Hoistway Doors, herein.

C. Frames: Fabricate from minimum 12 gage, Type 316 No. 4 brush finish stainless steel with side jambs in one continuous piece from sill to head section. Head and jamb fully welded mitered corner.

D. Front Return Panels: Provide full height 12 gage, Type 316 stainless steel, No. 4 brush finish, fixed returns.

E. Hangers and Tracks: Provide heavy-duty hangers and tracks that are sheave type with minimum two-point suspension to support the heavy vision panel doors. Provide steel sheaves with ball or roller bearings with resilient sound-absorbing tires and adjustable upthrust, flanged groove tracks. All material shall have anti-corrosive treatment. Maximum load per hanger shall not exceed 100 pounds. Additional hangers shall be provided as required. Hanger bolts shall be a minimum one-half inch diameter.

F. Headers, Struts and Closer Angles as required for entrance installation and door closer mechanism, shall be manufactured from plate steel. Use full-length steel struts. Hanger headers, minimum one-fourth inch thick material, shall extend from strut to strut with minimum three-eighths inch thick angles. All metal parts materials shall be galvanized.

G. Dust and Hanger Covers: Provide as required, 16 gage minimum, Type 316 stainless steel, No. 4 brush finish. Hanger cover plates shall extend full length of door track. All covers shall be removable using key hole style slots.

H. Fascia, Toe and Head Guards: Minimum 16 gage type 16 stainless steel, No. 4 brush finish, reinforced.

I. Sills: Provide sills constructed of extruded nickel silver alloy with non-slip surfaces and grooves suitable for guides. Installed sills shall be continuous from strut to strut. Welded parts are not acceptable. Mount the sills with recessed, flat head stainless steel screws or hidden “T” type fasteners. Provide a 16 gage stainless steel plate to cover the exposed vertical face of the elevator door sills. Provide all support angles, levelers and necessary concrete filler under sill and grouting for a complete secure, level, and plumb installation. No plywood shall be used under the hoistway sills. Apply silicone caulk around all gaps and on top of the fasteners to prevent any liquid from seeping into the underlayment or hoistway edging angle. Support angle and levelers shall be galvanized or stainless steel. Sill shall be supported along its entire width and length. All sills shall be mounted higher than finished floor to allow drainage of sill.

2.08 CAR AND HOISTWAY DOORS

A. General: All hoistway and car elevator doors shall be stainless steel with vision panels.

B. Door Panels: Car and hoistway door construction shall be reinforced structural steel with minimum 14-gage Type 316 stainless steel No. 4 finish cladding, flush design, rolled profile, construction to ensure rigidity. The door panel assembly and related equipment shall be designed to withstand the force requirement of ASME A17.1.

1. Provide full-length neoprene astragals on meeting door faces.
2. Mount doors on structural header, not on car enclosure.
3. Provide non-vision side wings of stainless steel, No. 4 finish.
4. Use torsion spring mechanical closures; do not use weight closures.
5. Door mechanisms shall not be visible in vision panels.
6. Exposed vertical door corners shall be smooth and seamless.
7. Provide rubber stops to limit travel of all doors, both direction.
8. Full height 12 gage stainless steel, fixed return panels.

C. Door protection: Refer to Article 2.09, Electronic Door Edge Sensor.

D. Door Guides: Door panels shall be guided at bottom with adjustable nonmetallic gibs sliding in a smooth threshold groove. Provide a minimum of two gibs per panel located one inch from each end. Gibs shall be secured with minimum two screws to bracket and bracket shall be secured to door with at least three stainless steel screws.

E. Vision Panels: Vision Panels shall be installed in such a way that vision panels on car and hoistway shall be aligned. Door vision panels shall be provided and installed in accordance with the following:

Vision panel shall be minimum ten inches wide and center mounted. The top of the vision panel shall be 60 inches above finish floor and the bottom shall be 18 inches above finish floor. The glass vision panels shall meet ANSI Z97.1 safety glazing materials used in building and CCR Title 8, Elevator Safety Order Section 3034 requirements.

1. Glass: Glass shall be ASTM C1048, Kind FT, Type I, Class 1, Quality q3, meeting ANSI Z97.1. The rating of the glass shall be visible in each panel. Lamination inner layer of 0.060 inch polyvinyl butyral. Both glass layers shall be tempered, clear, nine-sixteenths inch total thickness and shall be coated with anti-graffiti clear film coating.

2. Glazing Setting Blocks and Spacers: ASTM C864, semi-hard neoprene or vinyl rubber, 70 to 90 Shore A hardness when tested in accordance with ASTM D2240, of width equal to thickness of glass and long enough to limit load on each block to 15 psig. Minimum length of setting blocks shall be three inches.

3. Glazing Gaskets: Continuous, closed-cell, extruded neoprene manufactured for glazing in type of metal doors and frames. Color shall be black. Gaskets shall be capable of being compressed 40 percent of original size and shall have 100 percent recovery capability when tested in accordance with ASTM F36.

F. Hangers shall to be mounted to the doors with minimum one-half inch diameter bolts. Maximum load per hanger shall not exceed 100 pounds, additional hangers shall be provided as required. All fasteners shall be stainless steel. Finish of all door equipment shall be galvanized.

G. Door Operator: Door operator shall be heavy-duty, closed loop speed regulated Model MOVFR, manufactured by G.A.L. Inc., a Designated Matching Product. Structural support shall be independent of car enclosure with sound insulation. Door equipment and coverings shall be galvanized or plated. Wire relating cables shall be stainless steel.

1. Test switches shall be provided for the set-up and calibration for opening, closing, nudging and all speed adjustments. At least one hand-held programming tool shall be provided per elevator.

2.09 ELECTRONIC DOOR EDGE SENSOR

A. The door edge sensors shall be District Matching Product (DMP); “Pana 40 Plus” manufactured by Janus Elevator Products, Inc., and shall be installed in accordance with the manufacturer recommendation. Install the door edge sensors along the edge of elevator doors outside of the car door frame structures. With minimum six mounting brackets per door edge sensor.

B. Operation: The door edge sensor shall provide a full light curtain door protective system which does not rely on physical contact with, or the motion of, a person or object to inhibit door movement or initiate door reversal.

1. The system shall be able to detect a two-and-one-half inch diameter rod introduced at any position within the door movement and between the height of one inch above sill level and three inches below the car doorjamb.

2. Detection of intrusion into the protected area shall cause the doors, if fully open, to be held in the open position and, if closing, to stop and reverse to fully open position.

3. The first intrusion during a stop at any landing shall cancel the normal dwell time and substitute a door protective system time delay that shall be adjustable between one to 60 seconds commencing with removal of the intrusion. If, during this period, a further intrusion occurs, upon its removal, the same delay period shall apply and this cycle shall continue until traffic through the doorway ceases.

4. The doors shall commence to close immediately after the expiration of the determined period once the last intrusion has been removed.

5. If doors are prevented from closing for an adjustable period of 15 to 45 seconds, they shall proceed to close at reduced speed and a nagging buzzer within 75-85 decibels shall sound. Door closing force shall not exceed two and a half pounds-force when door re-opening device is not in operation.

6. If the system incorporates light beams, the light source shall not require the use of incandescent filament lamps but shall operate in the invisible portion of the light spectrum.

2.10 CAR ENCLOSURE

A. General: Provide complete car with appurtenances, appointments, and finishes as indicated. Finish work shall have smooth surfaces and free of buckles, scratches, dents, warps, squeaks and rattles. Joints shall be light proof. Fasteners shall not be visible except as indicated.

B. Car Walls: Car walls shall be stainless steel, no less than 14 gauge Type 316, NAAMM AMP 503 No. 4 finish, and reinforced structurally at least every 30 inches. Surfaces of the floor support, door guides, and wall panels up to 36 inches above platform shall be cleaned then treated with metal primer and rust prevention compound.

1. Vertical panels shall be reinforced to a minimum height of one foot by a steel plate with a thickness of one-sixteenth inch or greater.

2. Reinforce bottom of car wall and underside of door with minimum three by three by one-fourth inch galvanized steel angles.

3. There shall be a minimum three-inch cove base around the entire perimeter of the cab, including the door walls. The radius of the coving shall be a minimum of one-and-one-half inches.

4. Wood shall not be used anywhere in car, including floor and platform.

5. Vision panels shall be installed in car walls to align with hoistway walls. An additional handrail shall be provided in front of vision panel if the vision panel is on the side wall. Vision panels shall be constructed in accordance with Article 2.08 E.

C. Contractor shall furnish and install flooring in accordance with Article 2.11, Elevator Floor and Platform.

D. Hoistway Entrances at All Levels, under Sills. Car sill shall be slightly higher than the finish floor, but shall not exceed one-sixteenth inch. Sill and door pocket behind fully retracted door position shall have a smooth, upward curved surface to direct liquid back towards center of sill. Area of sill and door tracks behind door shall be accessible by a half inch diameter steam wand for cleaning and sanitation.

E. Ceiling: Unitized minimum 18 GA stainless steel construction with emergency exit in accordance with regulatory requirements.

F. Car Ventilation: For all elevator cars, Contractor shall provide exhaust fan with sound isolation mounted on car roof or as per manufacturer's recommendation. Fan shall be two-speed squirrel-cage exhaust blower rated 200 cfm, 120 Vac. Fan speed shall be selected by a key switch (keyed to EX 513) located in the maintenance panel in the Car Operating Panel.

G. Motion sensor: Contractor's attention is directed to Article 2.16, Recessed Motion Sensing Unit.

H. Car Lighting: Illumination level inside the car shall be minimum ten foot-candle measured at the floor level. Car lighting shall have T8 fluorescent light fixtures with luminous louver. Nor transparent plastic lenses are permitted. The related work shall be performed in accordance with Section 26 50 00, Lighting.

I. Emergency Lighting: Provide emergency lighting in accordance with CCR Title 8 and with a minimum five foot-candle level. Provide a charger-inverter battery unit with alarm bell mounted on top of car. The charger-inverter battery unit shall be gel-celled batteries providing 24 volts. Battery shall be sealed and have a ten year service life. The alarm bell shall be a six-inch gong and shall be mounted to the battery pack and meet the ANSI code requirements for audibility. The unit shall include a pilot light and test switch, off-on switch, and a terminal strip. Input voltage shall be 115 Vac continuous and the output voltage shall be 115 Vac with a maximum 100 watts capacity. Loads shall include the car emergency lighting, alarm bell, and the transformer unit for the CCTV camera. Upon outage of normal power the unit shall, within five seconds, light two lamps of the normal car lighting fixtures. The unit shall have sufficient capacity to keep the lights in continuous operation for four hours including the alarm and CCTV camera for one hour. Provide a readily accessible switch mounted in the service cabinet for testing the unit.

J. Car Operating Panel (COP): Elevators shall have two COPs located on each side of the door. Each COP shall be a stainless steel panel, with heavy duty, stainless steel spring-loaded hinges or continuous piano hinge, that is secured with flush barrel-type keyed latches keyed OEM to EX 514. Hinged Car Operating Panel when opened shall have a minimum three-inch clearance from the finished floor. Contractor's attention shall be directed to Article 2.15, Signals and Operating Fixtures, for related work.

K. Conduits and wires shall enter elevator car from top down, never from floor up.

L. Car Sill: As specified in Article 2.07, Hoistway Entrances at All Levels, under Sills. Car sill shall be slightly higher than the finish floor, but shall not exceed 1/16 inch.

M. Handrails: Shall be stainless steel, one-and-one-half inch tube or bar. Contractor shall also provide heavy duty stainless steel mounting brackets, fasteners, and other hardware. Fastening shall be three-eighths inch minimum in diameter. Each handrail shall support a minimum load of 200 pounds.

N. Car shall be sound isolated from car frame.

O. Car Camera: Refer to Article 2.17, Cameras, herein.

P. If the Engineer requests, car enclosure shall be pre-assembled at the factory prior to shipment for the Engineer's inspection.

2.11 ELEVATOR FLOOR AND PLATFORM

A. Car Frame and Platform: Provide structural steel frame with anti-corrosion primer and paint with gray finish color. Isolate platform from car frame by rubber pads and provide jacking bolts for pad replacement.

1. Allow recess for installation of finish flooring. Design platform and floor for 500 pounds concentrated live load, and 50 pounds per square foot.

B. Subfloor: Construct in accordance with standard drawing MS39 floor and Wall Details. The stainless steel floor pan shall be 11 gage and extending the entire floor area, including the cove base. Seams shall be staggered. The floor pan shall be sectioned where required and constructed with watertight seams, fastened to the substrate with stainless flat head screws, four inches on center from pan joints and 16 inches center to center. The floor pan fasteners shall be caulked, heads ground flush with pan surfaces and indented pan fasteners shall be covered with leveling compound. Concealed areas behind door returns shall be caulked.

C. Finish Flooring: Refer to Section 09 67 70, Elevator Spray-on Flooring.

D. Wood products will not be permitted anywhere inside or outside the elevator car.

E. All gaps and running openings where the platform structure meets the surface of the finished openings shall be within the tolerances specified in the Elevator Safety Orders.

F. Platform floor shall slope so that one quart of water poured onto the wall shall flow towards the car center so that liquid on the floor will not accumulate in the corners or near the floor perimeter of the car. The specified finish floor and stainless steel floor pan shall be constructed with watertight seams. There shall be no ridges or tripping hazards.

2.12 ELECTRICAL COMPONENTS

A. General: Electrical components shall comply with NFPA 70 and CCR, Title 24, Part 3, California Electrical Code. All wiring and conduit work shall be performed in accordance with Section 20 70 26, Common Materials and Methods for Electrical Systems, and Section 26 05 24, Low and Medium Voltage Wires and Cables, unless stated herein.

B. Weatherproofing: Electrical enclosures, penetrations and wiring shall be waterproof, NEMA 4 or 4X, unless otherwise specified. Wiring shall be in galvanized rigid steel (GRS) conduit with watertight fittings, except otherwise noted.

C. Raceways:

1. Fittings: Provide watertight fittings and hubs for all raceways and enclosures.

2. Provide mechanical protection for lighting fixtures on top and bottom of car, and in the elevator pit. Light fixtures shall be separately switched.

3. Raceways and conduits in hoistway shall be exposed. All conduits shall be galvanized rigid steel and minimum three-fourths inch. Liquid-tight flexible conduit may be routed to fixtures and switches, but shall not exceed 18 inches in length. Main hoistway raceway shall be hinged, NEMA type 12 wireway with zinc plated or stainless steel quick release hatches. Raceway joints shall be gasketed. Raceways shall be powder coated inside and out.

4. All terminal junction boxes in the hoistway and machine room shall be stainless steel, NEMA 4X. Pull boxes shall be powder coated steel enclosures, NEMA 12 or 4.

5. Electrical metallic tubing (EMT) is not permitted for elevator related work.

6. Conduits shall be routed along walls and ceilings.

D. Electrical Wiring:

1. Wiring shall be color coded and identified with permanent imprinted embossed sleeves at all terminations throughout, including controller and junction boxes. Terminal strips shall be identified with unique numbering that matches the controller schematic.

2. Conductors: Provide stranded copper conductors throughout, with individual wire color coded and/or labeled. Minimum wire size shall be 18 AWG. Conductors shall be designated uniformly throughout the system.

3. External connections to the equipment on each controller shall be made by means of approved cable thimbles or solderless cable lugs or both depending on the current carried (Amps) as approved by the Engineer.

4. Label each terminal and spares as they correspond to the controller schematic. Connections shall use insulated crimp connectors on terminal blocks located in control cabinets and junction boxes. The crimper shall be comparable to Panduit Model CT-550 or equal. Do not use splices or similar connections in any wiring except at terminal blocks. No more than three wires per terminal shall be allowed. Provide anti-corrosion protection compound on all high current connections throughout the system using a product comparable to Thomas & Betts #CP-16 or equal. All terminations shall be labeled.

5. Do not parallel conductors to increase current carrying capacity.

6. Do not use armored flexible metal conduit as grounding conductor.

7. Perform grounding of the elevator equipment in accordance with the manufacturer's instructions.

8. Provide dedicated conduits for the following circuits:

   a. Main power from the disconnect to the controller

   b. Motor power from the controller to the motor

   c. Speed encoder to the controller

9. Door interlock wiring shall be heat resistant and shall be continuous without splices or terminations to or from the controller.

E. Traveling Cables:

1. Provide two traveling cables between car and the controller via the remote junction in the hoistway. The steel support cable shall be flexible or extra-flexible, preformed, galvanized steel wire rope support strand. The steel core shall be insulated with polyvinyl chloride (PVC) and cotton braided. An overall jacket of PVC shall provide a smooth, flexible, abrasion-resistant covering. Cable shall comply with the flame test requirements in Paragraphs 1060.1 - 1060.9 of UL 1581 and shall be CSA FT-1 flame rated. The insulated conductors shall be soft annealed; bunched stranded, bare copper complies with ASTM B3 and B174. The conductors shall be insulated with a high quality 60 degrees C PVC and shall be rated at 300 Volts in accordance with the requirements of UL62, CSA C22.2 No.49 and NEC Articles 400 and 620. Provide a heavy duty, single eye, closed mesh multi-weave, stainless steel wire grip to support the traveling cable on both ends and properly anchor to relieve strain on individual conductors. Provide details of the cable attachments on each end. Protect cables from rubbing against hoistway or car parts. Observe minimum radius requirements.

2. One traveling cable (for power and control circuits) shall be continuous from elevator car to the controller in the elevator machine room via the halfway box. Provide a minimum of ten spare conductors of minimum #18 AWG and two spare conductors of #14 AWG, which shall be terminated at both ends to a terminal block.

3. The second traveling cable (for communication circuits and CCTV) shall be continuous from the car to the Communications Interface Cabinet in the elevator machine room via the halfway box. Provide a minimum of two pair spare #22 AWG communication conductors terminated to Krone style termination blocks. Minimum of one pair spare #14 AWG conductors terminated to terminal blocks, minimum two coaxial cables (the minimum cable count shall be increased to include one spare terminated to feed-through coaxial BNC connectors), one six fiber optical fiber cable which shall be terminated to fiber patch panel with LC style connectors. All cables shall be terminated at both ends. Route the coaxial and optical fiber cables and communication circuits in conduit to the Train Control Room or Communication Room.

4. The coaxial cable shall be 75-ohm exhibiting the characteristics of an RG6 and incorporate the added mechanical properties of a composite copper and copper-covered steel inner conductor, the deformation resistance of a cellular polypropylene dielectric, and a combination foil tape and copper braid for 100 percent shield coverage.

5. Communication circuits shall be a minimum one pair #14 AWG and six shielded twisted pair, 22 AWG, soft-annealed, bare copper cable with a non-insulated drain wire. The shield shall be a laminated polyester and aluminum foil tape. The assembly shall be covered with an overall colored nylon or PVC jacket. Terminate both ends of the circuits to a terminal block.

6. Optical fiber cable shall have Mean Cycles Between Failures (MCBF) of 40,000 for less than two decibel loss. Fiber cable shall meet the following requirements:

    a. Multimode fiberoptic cable shall be OM4 cable, or approved equal compliant to the IEC 60793-2-10, Type A1a.3 Fiber and TIA/EIA-492 AAAD standard.

    b. 50/125 micron tight-buffered multimode optical fiber, covered with high-strength aramid yarn and jacketed with flame retardant PVC.

    c. Operating wavelength and bandwidth 160MHz.km at 1300 nm.

    d. Attenuation at 850 nanometers 3.75 decibels per kilometer max.

    e. Attenuation at 1300 nanometers 1.00 decibels max.

    f. Core diameter 50 micrometers plus or minus two micrometers optimized for 550 meters.

    g. Cladding diameter 125 micrometer plus or minus two micrometeres.

    h. Optical performance: The attenuation shall be measured in accordance with EIA TIA-455-61. The bandwidth shall be measured in accordance with EIA TIA-455-30 or EIA TIA-455-51.

F. Communications Interface Cabinet (CIC): Provide one or more NEMA 12, powder coated steel junction boxes mounted in a secure location where the District's authorized personnel can access.

1. The cabinet shall be equipped with a 115VAC, 15A breaker connected to four fused terminals and four auxiliary outlets.

2. The cabinet shall terminate the communication and control circuits that are routed between the elevator controllers and other equipment and shall include but not be limited to circuits such as: fire alarm, station agent booth controls and indication, CCTV, emergency phone, remote monitoring signals, and seismic switch.

3. Terminations shall be on a DIN rail mounted terminal strip unless specified otherwise herein, with each termination labeled. System circuits shall be grouped together on separate terminal boards or separated by two spare terminals between different systems.

4. Provide feed-through coaxial BNC connectors mounted on a L-shape channel inside the junction box.

5. Provide conduit from CIC to train control room for communication cables as specified in Contract Drawings.

G. Main disconnect Device: Provide a heavy-duty fused safety disconnect switch or a circuit breaker capable of being locked in the "OFF" position for each elevator in the machine room. The safety switch shall be sized for the total motor and controller electrical loads. The disconnect shall incorporate a micro switch so that when the disconnect is opened, the lowering device does not operate. The disconnect shall be located adjacent to the machine room door.

H. Car Inspection Station: Provide a car top inspection station to operate the car from the top. The inspection station shall include control switches for up, down, run, inspect, and stop and shall include an audible and visual alarm for emergency service. Inspection station shall also include a gasket sealed light fixture with a 25-watt compact fluorescent lamp with wire guard, glass globe and switch and provide a 20A, 120V GFCI duplex receptacle with weather-resistant cover and flip-lids.

I. Work Lights and Convenience Outlets: Provide the following:

1. Top of car: 15Amp, 120Vac, GFCI duplex receptacle on car top for CCTV camera power supply in weather-resistant outlet box with flip-lids.

2. Underside of car: Gasket sealed light fixture with a LED lamp with wire guard and switch and a 20Amp, 120Vac GFCI duplex receptacle with weather-resistant cover and flip-lids. Fixture shall be accessible from the lowest hoistway landing.

3. Inside car: 15Amp, 120Vac, GFCI duplex receptacle in the car service panel.

4. Hoistway: At the top of the hoistway and in the pit, provide a gasketed, sealed, 48 inch long light fixture with a lamp with wire guard and switch. Light switches shall operate both hoistway light fixtures and be enclosed in weatherproof box with flip-lids. Provide in hoistway pit a minimum of two duplex receptacles (20Amp, 120Vac) with GFCI protection in weather-resistant outlet box with flip-lids. Receptacles at the elevator pit shall be installed 36 inches above the pit floor.

5. Elevator Machine Room: Provide a minimum of two duplex receptacles (20Amp, 120Vac).

J. Provide the necessary red lockable safety switches to isolate 120 Volt power for auxiliary systems in the elevator car, such as car lighting, cameras and outlets. Mount switches in the elevator machine room adjacent to the controller. At the switches, label the power source and function for each switch.

K. Main Circuit Breaker: If a sprinkler system is installed in the hoistway 24 inches above pit floor or machine room, then the main 480 Volt circuit breaker shall be supplied with a shunt trip feature to isolate the main power supply to the elevator prior to the activation of the fire sprinklers. The shunt trip shall be activated by heat detectors in the machine room and hoistway by means of the main fire alarm panel.

L. Provide a battery lowering system to activate as soon as power is lost. The elevator will make one trip on battery power to a nearby floor or in most cases the ground floor. The doors will open properly, and the elevator will safely shut down.

M. Provide seismic switch. Upon activation, all elevators shall go to the nearest floor, open door and shut down. The elevator shall remain on Seismic Operation after restoration of normal utility power. An elevator can be returned to service with the reset button, provided the displacement switch is not activated.

2.13 CONTROLLER

A. General: The work of this section shall be performed in accordance with Section 20 70 26, Common Materials and Methods for Electrical Systems.

B. Controller: The programmable controller shall be a non-proprietary, micro-processor driven Motion 4000, DMP, for hydraulic elevators. Controller shall be equipped, at a minimum, with the following features:

1. Computer controlled motion of the elevator including acceleration, top speed deceleration, and two-way leveling.

2. Serial microprocessor cart-top and COP boards.

3. Fire fighter’s service phase 1 and 2.

4. Hall board serial link.

5. Door operating circuitry for door operators.

6. Motor feedback encoder circuitry.

7. Load weighing.

8. Voice annunciation.

9. Solid-state motor starter.

10. Isolation transformer.

C. Controller Panel: The controller panel shall be provided with a date pocket made of high impact thermoplastic mounted behind the door panel with three point latches and lockable. The controller cabinets shall be NEMA 4X with minimum eight-inches floor stands and provided with the technical data, instruction manuals, and other related materials about the controller enclosed therein. Provide two hand-held programming tools per facility.

D. Refer to Article 1.07, Design and Operation Requirements, under Elevator Controller, for operational requirements.

E. Each controller shall generate external indicating signals required by the remote monitoring system. Provide a terminal block in the controller cabinet and hard wire the remote monitoring system events' list. These event indicating signals shall be available from the termination points, i.e., dry RMS contact relay, such that the specified elevator fault and status event data can be automatically received by the existing District's Remote Escalator/Elevator Central Monitoring System (EERMS).

F. The elevator controller shall be field marked with the maximum available fault current along with the date the calculation was made. Furthermore, if there is a change to the short-circuit current rating SCCR, then this field marking must be revised.

2.14 REMOTE MONITORING SYSTEM

A. The Contractor shall provide the signals to report any failures or out of service conditions to the existing District's Escalator/Elevator Remote Monitoring System. The existing EERMS was developed and is owned by the District. The EERMS communicates with the elevator controller located in the Communications Interface Cabinet.

B. The Communications Interface Cabinet shall be equipped with remote input and output modules which meet the specification of the Designated Matching Products. The remote input and output modules shall have minimum of input and output quantities required in Section 2.14C with the additional 20 percent spare.

C. Fault and Event List: The controller shall provide the following signals to the DeviceNet modules. These signals shall be reported instantaneously as the controller responds to the initial signal within the elevator system. In the event a monitored condition cannot be determined directly from the controller, the Contractor shall provide the necessary sensor device. The following safety circuits and conditions ("Events List") shall be established for reporting.

1. Door Lock
2. Loss of Power
3. Safety Circuit
4. Emergency Stop Button
5. Emergency Service (Fire Alarm or Earthquake)
6. Car at Top Landing
7. Car at Middle Landing (If applicable). If more than three landings, parallel all intermediate floor, and connect as Middle.
8. Car at Bottom Landing
9. In Service (ISV and ISRT signals in parallel)
10. Low Oil Level in Main Reservoir
11. High Oil Level in Collection Tank
12. Car Shutdown by Agent
13. Car Occupied
14. Mechanic On-Site (door switch and ISV signal)

2.15 SIGNALS AND OPERATING FIXTURES

A. General: Contractor shall provide fixtures and signals as follows, test complete system, correct any deficiencies in wiring and function and make complete system fully functional. Location and arrangement of fixtures and signs shall comply with the ADA and other code requirements.

B. Push Buttons:

1. Provide stainless steel, vandal resistant push buttons for each landing, door open, door close, car alarm and emergency phone call. Metal button top surface shall be flat and raised one-eighth inch from surface. Metal buttons for hall call shall be through-engraved with illuminated direction arrows. An illuminated halo shall surround the push buttons. Halos surrounding the alarm and phone buttons shall be red. Button illumination shall be long-life, standard wattage LED. Push buttons for all car and hall, alarm, and hands-free phone shall be Innovation Industries Type PB 30, a Designated Matching Product (DMP). Push button assembly for non-illuminated functions, door close, door open shall be Innovation Industries Type PB 20, a Designated Matching Product (DMP) or as required by the Engineer.

2. Operation of hall call button shall cause button to illuminate until car arrives. Operation of car call button shall cause button to illuminate until car reaches other landing.

C. Car Operating Panel (COP):

1. Refer to BFS standard drawings for layout and details.

2. COP Faceplates: The faceplate shall be stainless steel, No. 4 finish, one-eighth inch minimum thickness, flush mounted. Refer to standard drawings for layout and details.

3. COP Etchings: Except for pushbutton markings, all text shall be etched in faceplate and back-filled with black paint. Text related to the fire service shall be back filled with red paint. Lettering shall be as large as possible, but a minimum of one-fourth inch, unless otherwise indicated.

   a. Fire Service II instructions shall be etched in red lettering.

   b. The elevator number shall be etched into the faceplate with minimum one-half inch, black filled lettering. Elevator identification shall include the Station number for example “A20, Elevator No. 34”. The correct elevator number will be assigned by the Engineer.

   c. “No Smoking “shall be etched with minimum one inch, red lettering.

   d. Elevator capacity shall be etched in black lettering.

4. COP Nameplates: Provide raised Braille Grade II, standard alphabetical characters for numerals or symbols as indicated to the left of the operating buttons and devices used by the public, in compliance with the Americans With Disabilities Act. Raised characters shall be white metal on black background without borderline on edges. Braille plates shall be surface mounted on control panel with concealed mechanical fasteners.

5. Fastening shall be flush, stainless steel tamper-proof screws of material matching faceplates.

6. Car alarm button: Provide dry contact for alarm initiation to Station Agent’s Booth Annunciation console. Activation of alarm button shall illuminate button as well as activate car alarm bell, by closure.

7. Car Position Indicators: Contractor shall provide a digital programmable position indicator in the Car Operating Panel. The displayed landings shall correlate with the push button nameplates and provide a directional arrow that shall be illuminated only while moving.

8. Exposed key switches shall be provided for the car stop switch only. See Article 2.15 G herein for key type.

9. Door shall have a permit holder with a minimum display window size of eight-and-three fourths inches wide and four-and-one-half inches high.

D. Service Cabinets: The Contractor shall provide a service cabinet in the Car Operating Panel. The service cabinet shall be behind a minimum ten-gage stainless steel hinged door with gasket seal. Keying shall be EX 513. The service cabinet shall be mounted with hairline joints to car wall surface and have no unfilled openings. The service cabinet shall provide the following:

1. Inspection Service key switch, EX 514
2. Independent Service key switch, EX 513
3. Car light on/off key switch, EX 513
4. Motion Sensor mode key switch EX 513
5. Fan Speed high, off, low key switch EX 513
6. Emergency Light illuminated test button
7. Duplex GFI receptacle
8. Fire service panel and fire service keying all EX 515

E. Emergency Car Hands Free Telephone: Contractor shall furnish, install and test hands free telephone as required by Section 27 30 01, Telephone Systems. Provide all work necessary to install the system to satisfactory operation.

1. Telephone panel shall include a text and Braille emergency telephone nameplate.

F. Hall Fixtures.

1. Chimes: Provide single chime for up and double chime for down direction. Chime volume shall be at least 75 decibels measured five feet from the hoistway door.
2. Hall lantern shall illuminate when car arrives. Green for up, red for down. Provide vandal resistant, long-life LED directional lanterns with stainless steel faceplate. Provide both “up” (one signal) and “down” (two signals) arrow-shape signals at landings of two-way travel. Light extinguishes when doors close. Lanterns shall not be mounted in the doorjamb.
3. Hall Call Panel: Provide hall call push buttons at each landing as specified herein under “Push Buttons”. Mount in a minimum one-eighth inch thick stainless steel faceplate. Surface mount faceplate with tamper proof fasteners. Hall call stations shall be located on right side of hoistway entrances at single elevator locations and be centered between entrances at group of elevators. Hall calls shall be identified with “Elevator Call” labels below the button. Labels shall include Braille lettering. Main floor hall call panel shall be equipped with fire service key switch and instructions. (Refer to Article 2.15 G, Keys and Key-Operated Switches, for specifications for key switch.) Hall call panels at each level shall have the required “do not use in case of fire” instructions. All emergency instructions shall be etched in stainless steel faceplate and back-filled with red epoxy paint.

Wording as approved by the applicable Fire Marshal. Pictorials shall be supplied with the wording.

G. Keys and Key-Operated Switches: Keys in the car and at hoistway entrance shall be round barrel, Fort Lock EX series keys to match District standard keys. The Engineer will provide specific key assignment. Key-operated switches shall be in compliance with regulatory requirements. Coordinate keyway and keying requirements with the Engineer. Keying shall be compatible with the existing BART lock system. BART keys for key operated switches and locks to be GEM, Fort lock, Chicago, barrel keys. Fire recall key-operated switch shall be on integral hall call fixture at Main floor.

H. Station Agent's Booth Elevator Monitoring and Control (SABEMC): SABEMC is part of the station SCADA and station agent booth panel. Contractor shall provide signal wires specified in Article 1.08 from the elevator controller to the input and output modules in the CIC. Provide a thick DeviceNet cable or District-approved communication cable(s) from CIC to the SCADA equipment in the Train Control Room. Provide conduits and conductors to route required elevator indications and controls to the station agent's booth. Refer to the District Technical Manual – SCADA System Function Description.

2.16 RECESSED MOTION SENSING UNIT

A. The motion sensor shall be the District Designated Matching Product (DMP), CI-200, Version 2, 360o PIR occupancy sensor as manufactured by The Watt Stopper, Santa Clara, CA 95050. The motion sensor unit shall be recessed into the ceiling and routing of the control cable shall be in accordance with the Contract drawings. Provide a mounting bracket flush to the ceiling for the motion detector unit. The motion detector shall be located and adjusted so that movement of the doors does not generate a false occupancy. Provide the 120 Vac-power supply to the power pack unit of the motion detector.

B. Programmed Operation: If after a programmable length of time of 5 to 90 seconds an elevator car call has not been activated and the sensor detects elevator car occupancy, the car shall be programmable to proceed with either one of two courses of action. The choice of action shall be selectable by the motion detector key switch in the service panel on the Car Operating Panel. The logic and circuitry of this alarm shall be incorporated into the controller circuit. Any auxiliary relay contacts required to accomplish this feature shall be provided. This circuit shall be depicted in the schematic diagram of the controller. All occupancies, regardless of operation, shall be reported to the Station Agent's Booth.

C. Automatic Car Call Mode: Upon occupancy detection, the elevator shall automatically generate a car call to the opposite floor or next floor if a car call is not activated within an adjustable time of five to 30 seconds.

D. Nuisance Occupancy Mode: If an occupancy is detected without a car call for an adjustable time of five to 30 seconds, then the doors shall reopen and remain open with audible alarm until a car call or hall call is generated or the car is vacated.

2.17 CAMERAS

A. General: Provide cameras as specified in Section 28 41 29, Closed Circuit Television Systems. Camera circuits shall be routed through the Communications Interface Cabinet in the machine room and to the Train Control Room or Communications Room via a dedicated CCTV conduit.

B. Car camera: A camera shall be mounted in the ceiling corner on the front wall opposite of the side of the main Car Operating Panel. The camera shall be adjusted to observe patrons operating the main Car Operating Panel. The camera shall be housed in a vandal resistant enclosure.

C. Elevator Entrance Cameras: A camera shall be provided for each elevator entrance. Cameras shall be located at least eight feet above the finish floor and adjusted to view the entire entrance. Outdoor locations shall have a waterproof enclosure.

2.18 SIGNS

A. General: Hoistway and car signs shall be stainless steel plates with black backgrounds and raised white lettering and Braille symbols with raised white borders, unless otherwise specified. Braille lettering shall be CA Grade II, comply with the Americans With Disabilities Act and shall be located below alphabetical characters, numeral, or symbols. Signs shall be on separate plates flush-mounted with hairline joints and concealed mechanical fasteners in cars and surface-mounted with tamper-proof fasteners at elevator entrance locations.

B. Provide stainless steel signs with Braille indicating landing identification on both sides of the hall door jamb at every landing. Signs shall have black background and white lettering. Lettering shall be two inches in height and centered 60 inches above doorsill. Signs shall be surface-mounted with dimensions of four inches by four inches with corners of 1/16 inch radius.

C. Provide Star of Life Signs on each side of doorjamb at the main landing. Signs shall be raised blue lettering and standard star of life symbol on a white background.

D. Refer to “Hall Call Panel” under Article 2.15, Signals and Operating Fixtures, herein for requirements for “Elevator Call” signs with Braille at each hall call station.

E. Provide “Station Agent Call” sign with Braille on hands-free white courtesy phones located near elevator entrances to avoid confusion between hall call stations.

F. Provide black laminated plastic sign with one-and-one half by five inch lettering centered on each hoistway entrance header indicating the elevator number. Sign shall be without Braille and abbreviated as the following example: “A20, ELEV. #33”.

2.19 VIBRATION ABSORPTION MOUNTS

A. Vibration Isolation: Minimum two inch thick vibration-absorption mounts, designed to effectively prevent the transmission of vibrations to the structure, and thereby eliminate the sources of structure-borne noise resulting from the elevator system. Indicate vibration isolation material on all drawings.

PART 3 – EXECUTION

3.01 PREPARATION

A. Hoistway: Examine the hoistway and supporting structure, and the conditions under which the elevator work is to be installed. Do not proceed with elevator installations until unsuitable conditions have been corrected. Hoistway pit shall be painted prior to installation of elevator equipment.

B. Electrical: Examine areas to receive elevators and verify that electrical rough-in is correct.

C. Machine Room walls and floor shall be painted prior to installation of elevator equipment.

D. Confirm that applicable submittals have been approved and applicable permits obtained prior to installation. Equipment installed without approved submittals shall be subject to possible rejection and removal at no to cost to District.

3.02 INSTALLATION

A. Welded Construction: Provide welded connections for installation of elevator work where bolted connections are not required for subsequent removal or for normal operation, adjustments, inspection, maintenance and replacement of worn parts.

B. Vibration Isolation: Mount rotating and vibrating elevator equipment and components on vibration-absorption mounts.

C. Lubricate operating parts of systems as recommended by manufacturers.

D. Alignment: Coordinate installation of hoistway entrances with installation of elevator guides rails for accurate alignment of entrance with car.

1. Adjust sills and doors to provide smooth, quiet trouble free operation.

2. Ensure guide rails plumb and parallel with maximum deviation from rail center-line of 1/16 inch per floor, noncumulative.

3. Install buffers with required blocking and supports.

4. Grout sills with non-shrink grout. Set units accurately aligned with finished floor at landings.

5. Mount sill plate with concealed fasteners.

6. Field repair damaged coatings and wrappings.

E. Controller: External connections to the equipment on each controller shall be made by means of approved cable thimbles or solderless cable lugs, or both, depending on the current to be carried.

F. Set PVC casing and cylinder. Extend inner casing above pit floor for snug fit against pit channels.

G. Backfill voids between outer steel casing and PVC liner with clean dry neutral silica sand, well tamped. Space between PVC and cylinder shall be left void.

H. After cylinder is set, provide a watertight hydraulic laminating or epoxy resin seal between casing and cylinder to a minimum depth of ten inches.

I. Plunger shall be installed straight, square, and plumb, and operation shall be free of any scraping, bumping, sticking or any irregular noises.

J. Install Sch 20 to outer steel casing with welded one-half inch thick bottom. Minimum two feet concrete plug is also acceptable provided it ensures casing is water tight.

K. Sound Reduction:

1. Mount insulation panels on sides of power unit frame. Air-borne noise from motor and pump assembly shall be isolated.

2. Provide two or more sound isolation couplings in machine room oil line, between pump and jack.

L. Balance car to ensure equal guide shoe pressure on all shoes. Do not exceed manufacturer’s recommendations.

M. Coordinate with the Engineer to install and test connections between the elevator and the train control room, communications room, and station agent’s booth as needed.

N. Controllers shall have six inches minimum clearance on all four sides (not including front and back).

3.03 FIELD QUALITY CONTROL

A. General

1. Notify the Engineer at least five Days prior to each scheduled test. Perform testing in the presence of the Engineer.

2. Regulatory Agencies Inspection: Upon completion of the elevator, Contractor is responsible to provide instruments, weights and personnel to conduct tests required by regulatory agencies. Representatives of the regulatory agencies and the Engineer shall witness tests.

3. Overall elevator testing shall be performed after installation.

4. Contractor shall perform all safety tests on the elevator without load. All tests shall be recorded in detail and submitted to the Engineer for approval.

B. Acceptance Testing Requirement

1. The emergency phone, seismic switch, and fire service operation shall be tested prior to the State Inspection to ensure that these devices are communicating as intended with the BART operating system.

2. A one-hour heat and run test with full load shall be performed prior to State inspection. Performance and leveling tests shall be made before and after heat and run test. Heat and run test shall not exceed manufacturer's recommendations.

3. All the Station Agent's Booth signals and functions and EERMS signals and functions shall be tested.

4. Contractor shall conduct NEII-1 performance tests with its own calibrated equipment as approved by the Engineer. Test results shall meet or exceed NEII-1 and shall be submitted to the Engineer for approval. The Engineer my witness the tests.

5. Measure and record acoustical output levels in machine room and both inside and outside of car to ensure Contract requirements are meet.

6. Contractor shall test direction indicator system for proper operation.

7. Test hydraulic piping per Section 20 10 13, Common Materials and Methods for Facility Services, Fires Suppression, Plumbing and HVAC.

C. Substantial Completion Inspection: District personnel will perform a full operation and quality control inspection, known as the Substantial Completion Inspection, after the above items been completed. This inspection may occur prior to or after the State inspection. However, Substantial Completion certificate for the elevator will not be granted until the State issues an operating permit and all significant and most other punchlist items identified during the Substantial Completion Inspection have been corrected and approved by the Engineer.

D. Final Acceptance Inspection: After the completion of the punch list items, submission and approval of all deliverables, including Operating and Maintenance manuals, training, and the Maintenance Period is nearing completion, the Contractor shall notify the Engineer at least two weeks in advance to schedule the Final Acceptance inspection. This inspection will verify that the punch list items have been completed and the elevator was properly maintained and is in good working condition.

E. Corrections: Make corrections to defects or discrepancies at no cost to the District. Should discrepancies be such that re-examination and re-testing is required, the Contractor shall pay for costs including those of the Engineer.

F. Contractor shall provide a complete list of all parameter settings.

3.04 MAINTENANCE

A. The Contractor shall perform maintenance service for the elevator in accordance with Article 1.12, Maintenance Services.

3.05 CLEANUP DURING CONSTRUCTION

A. The Contractor shall keep elevator area, elevator machine room, and the space allocated to the Contractor's work in a neat, safe and orderly condition.

3.06 FINAL CLEANING OF FACILITIES

A. Refer to Section 01 74 14, Cleaning. Contractor shall keep elevator area, elevator machine room, and the space allocated to the Contractor's work and storage in a neat safe and orderly condition. The Engineer may, at any time during construction order a general cleanup of the site as a part of the Work, and there shall be no additional cost to the District therefore. The Contractor shall provide general daily clean-up and disposal service for removal of waste, rubbish, trash, and debris away from the jobsite. Prior to final inspection by the Engineer, and after all elevator work is essentially complete, thoroughly clean facilities including hoistway enclosures and car, utilizing professional building cleaners where appropriate.

3.07 TRAINING

A. The Contractor shall provide either a Controller Simulator approved by the Engineer, which will become District property, or a program to train the District's operations, maintenance or training personnel in details of the elevator components which were installed or modified to enable the District to operate, service and maintain the elevators. In regard to the work of this Section, these provisions supersede Section 01 79 00, Demonstration and Training. As a minimum, training topics shall include controllers, door operators, and drive system. Training shall consist of one, four-hour familiarization session for a ten-person group. Training shall include an overview of the system installed, highlighting any portion of the installation unique to the location with a questions and answers period.

1. The Training Program shall include formal and informal instruction, as appropriate, and any models, mockups, documentation, and aids necessary to carry out the program.

2. Materials used in the Training Program shall be of durable construction and shall become the property of the District.

3. Assumptions:

    a. The Contractor shall assume that the personnel to be trained have only the basic skills pertinent to their craft as outlined in the District's job descriptions for the involved personnel.

4. Training Program: The Training Program Plan shall be submitted, subject to approval by the Engineer, within 30 Days of Substantial Completion and shall contain, at a minimum, the following data:

    a. A flow diagram indicating the logical progression of training to be conducted.

    b. A description of each course, including the number, description and duration for each lesson in the course.

    c. Resumes showing the qualifications of the proposed instructors. Instructors shall demonstrate a complete and thorough technical knowledge of the material being covered in the course. These instructors shall be thoroughly familiar with handbooks, guides, tools, test equipment, and other aids used in troubleshooting and repairing the equipment.

    d. A list of all subcontractors or other equipment manufacturers to be used in the training program and a description of their responsibilities.

    e. Complete written and practical tests to be administered at the conclusion of each course module and grading system to evaluate the proficiency of each trainee. The grading system shall identify needs for further training as needed.

    f. All third party training materials which are proposed to be included in the training program.

    g. Draft of the training manual.

B. General: The training shall be provided to the District personnel with the operating procedures necessary to operate the systems. The courses shall include, but not be limited to, the following training:

1. Classroom training shall give course participants an understanding of the overall system operation.

2. Hands-on training shall give course participants actual maintenance experience.

C. Courses: Training shall consist of the Elevator System Maintenance Course:

1. The Elevator System Maintenance Course shall provide the District's maintenance workers and trainers with detailed knowledge of and hands-on experience with the system functional capabilities and overall operation in order to properly troubleshoot and maintain the following components: controller, door operators, drive components, signal, and safety devices. The course shall provide participants with a working knowledge of these items and its operation, maintenance, interfaces, and use of test equipment for diagnosing troubles.

2. The course shall provide theoretical background and hands-on experience in troubleshooting and repair procedures to permit participants to locate and repair system faults in a time-efficient manner. Course shall include emergency provisions, including emergency access and procedures to be followed at time of failure in operation and other building emergencies. It shall train personnel in the procedures to be followed in checking the source of operation failure or malfunction. Operation of diagnostic equipment needed shall be explained.

3. The course shall utilize the complete Operation and Maintenance Manual.

4. The course shall utilize actual hardware and photographs taken during the manufacturing process wherever possible. Actual hardware used for training must pass re-inspection and acceptance testing prior to being placed in service.

5. The course shall consist of a minimum of eight hours of classroom training and eight hours of hands-on in the field training. The training shall not exceed eight hours per Day.

6. The course shall be presented a total of four times: The Contractor shall present first session within 60 Days after the substantial completion of the first elevator. The final session shall be no later than 120 Days after the first session.

7. Each class shall accommodate up to ten participants per session.

D. Training Location and Classrooms: All training courses shall be conducted in facilities provided by the District. The facilities will be equipped with tables and chairs. The Contractor shall provide video players and projectors as required.

E. Instructors: Contractor shall provide qualified instructors. The instructors shall have previous formal classroom instruction training and relevant experience with the provided systems equipment in an operating environment:

1. The instructor shall present classes and instructions in person.

2. When prerecorded lectures are part of a training course, the instructor shall supplement the recorded material as needed to make it relevant to the actual installation being taught.

3. The instructors shall demonstrate a complete and thorough technical knowledge of the material being covered in the course. All instructors shall be thoroughly familiar with the handbooks, guides, tools, test equipment, and other aids used in troubleshooting and repairing the equipment.

F. Training Manuals and Equipment: Prepare training manuals to supplement the Operation and Maintenance Manuals and submit them to the Engineer for review and approval at least 90 Days prior to the start of classroom instruction. The training manuals shall be prepared specifically for use as training aids. The Operation and Maintenance Manuals shall be the primary text.

1. Each course participant shall receive copies of the Operation and Maintenance Manual, Training Manuals, and other pertinent material prior to the commencement of all courses.

2. In addition to the copies provided for trainees, the Contractor shall provide the master and two additional copies of all Training Manuals and class materials as reference documentation.

3. Upon completion of each course, Operation and Maintenance Manuals, Training Manuals, and Training Aids shall become the property of the District. Throughout the Contract and warranty periods, it shall be the responsibility of the Contractor to supply the District with any changes and revisions to the Training Manuals and other documentation.

4. The District reserves the right to copy all training materials and aids for use in District conducted training courses.

5. The Contractor shall provide all special tools; equipment, training aids, and any other materials required to train course participants. The number of special tools and other training equipment shall be adequate for the number of participants attending each course session (up to 40 in all).

6. The District will provide the Contractor written feedback comments on the Training, Training Manuals and equipment based upon the first sessions. The Contractor shall incorporate the comments and resubmit the documents 60 Days prior to the last training sessions.

G. Videotaping:

1. Provide video training tape(s) covering complete troubleshooting of elevator drive/fault finder system for use by District’s Instructors.

2. In addition, the Contractor may utilize prerecorded lectures as supplementary training material. These shall not serve as a replacement for a classroom instructor or as the primary training vehicle. The Contractor shall provide such videotapes to the District for retention and playback by the District’s Instructors as reference documentation.

3. The District shall have the right to videotape training courses presented by the Contractor. The District shall also have the right to use these videotapes to train personnel in the future.

H. Final training documentation:

1. Updated and corrected Training Manuals and attachments as specified.

2. Sets of participant’s materials, 30 Days prior to commencement of training. Quantity of materials per class size specified herein.

3. Any models, mockups, simulations, or other material to conduct the training program.

END OF SECTION 14 24 00

SECTION 14 31 00

ESCALATORS

PART 1 – GENERAL

1.01 GENERAL DESCRIPTIONS

This Section includes requirements for Design, Fabrication, and Installation of Escalators to be installed on BART property.

A. Trusses.

B. Drip Pans.

C. Step Drive Units.

D. Tracks.

E. Driving Machine and Motor.

F. Controller and Wiring.

G. Safety Device and Switches.

H. Brakes.

I. Steps.

J. Step Demarcation Lights.

K. Step Chains.

L. Rollers.

M. Comb Teeth.

N. Handrails and Handrail Drive Systems.

O. Landing Plates.

P. Balustrades.

Q. Skirt Panels.

R. Deck Covers and Moldings.

S. Remote Monitoring Systems.

T. Energy Efficient Motor Controller.

1.02 RELATED SECTIONS

1. Section 05 05 22, Metal Welding
2. Section 05 12 00, Structural Steel Framing
3. Section 20 70 26, Common Materials and Methods for Electrical Systems

1.03 MEASUREMENT AND PAYMENT

A. Measurement

1. Escalators will be measured for payment on a lump sum basis for all escalators.
2. All spare parts will be measured for payment on a lump sum for escalators spare parts.
3. Maintenance will be measured for payment on a per escalator per month basis. Maintenance shall include required updates of Operation and Maintenance Manuals.
4. Chargeable Repairs shall be based on approved maintenance reports and shall be paid under the Allowance for Chargeable repairs.
5. All other items of the Work of specified in this section will not be measured separately for payment, but will be considered incidental to the Work.

B. Payment

1. Escalators, spare parts and Maintenance will be paid for at the contract unit and lump sum prices for quantities as determined by the measurement methods specified above.

1.04 REFERENCES

A. American National Standards Institute (ANSI):

1. ANSI B18.12 Glossary of Terms for Mechanical Fasteners

B. American Society of Mechanical Engineers (ASME):

1. ASME A17.1 Safety Code for Elevators and Escalators
2. ASME A17.2 Guide for Inspection of Elevators, Escalators, and Moving Walks
3. ASME A17.5 Elevator and Escalator Electrical Equipment
4. ASME B18.12 Glossary of Terms for Mechanical Fasteners

C. American Society of Civil Engineers (ASCE):

1.	ASCE/SEI 7	Minimum Design Loads for Buildings and Other Structures

D. American Society for Testing and Materials (ASTM):

1.	ASTM A123/A123M	Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
2.	ASTM A153/A153M	Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
3.	ASTM A385	Standard Practice for Providing High-Quality Zinc Coatings (Hot-Dip)
4.	ASTM A653/A653M	Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
5.	ASTM A780	Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
6.	ASTM A1008/A100M	Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable
7.	ASTM B209	Specification for Aluminum and Aluminum-Alloy Sheet and Plate
8.	ASTM B117	Standard Practice for Operating Salt Spray (Fog) Apparatus 10
9.	ASTM B211	Specification for Aluminum and Aluminum-Alloy Rolled or Cold Finished Bar, Rod, and Wire
10.	ASTM B221	Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rod, Wire, Profiles, and Tubes
11.	ASTM B308/B308M	Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles
12.	ASTM B633	Specification for Electrodeposited Coatings of Zinc, on Iron and Steel
13.	ASTM D412	Test Methods for Vulcanized Rubber and Thermoplastic Elastomers – Tension
14.	ASTM D1149	Test Methods for Rubber Deterioration – Cracking in an Ozone Controlled Environment

15. ASTM D2794 Testing Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact)

16. ASTM E18 Standard Test Methods for Rockwell Hardness of Metallic Materials

17. ASTM E84 Test Method for Surface Burning Characteristics of Building Materials

18. ASTM E136 Test Method for Behavior of Materials in a Vertical Tube Furnace at 750 degrees Celsius

19. ASTM E384 Standard Test Methods for Microindentation Hardness of Materials

20. ASTM F593 Standard Specification for Stainless Steel Bolts, Hex Caps Screws, and Studs

21. ASTM F594 Standard Specification for Stainless Steel Nuts

E. American Welding Society (AWS):

1. AWS D1.1 Structural Welding Code - Steel

F. American Bearing Manufacturers Association (ABMA):

1. ABMA STD 9 Load Ratings and Fatigue Life for Ball Bearings

2. ABMA STD 11 Load Ratings and Fatigue Life for Roller Bearings

G. Military Specifications (MIL):

1. MIL-P-21035 Paint High Zinc Dust Content, Galvanizing Repair (Metric)

H. National Association of Architectural Metal Manufacturers (NAAMM):

1. AMP 503 Finishes for Stainless Steel

I. National Electrical Manufacturers Association (NEMA):

1. NEMA AB 1 Molded-Case Circuit Breakers and Molded Case Switches, and Circuit-Breaker Enclosures

2. NEMA PB 1 Panelboards

J. National Fire Protection Association (NFPA):

1. NFPA 70 National Electrical Code

2. NFPA 101 Life Safety Code

3. NFPA 130 Standard for Fixed Guideway Transit and Passenger Rail Systems

If NFPA code conflicts with ASME A17.1 requirements, A17.1 shall prevail.

K. Steel Structures Painting Council (SSPC):

1. SSPC-SP 3 Power Tool Cleaning

2. SSPC-SP 6 Commercial Blast Cleaning

3. SSPC-CS 23.00 Specification for the Application of Thermal Spray Coatings (Metallizing) of Aluminum, Zinc, and their Alloys and Composites for the Corrosion Protection of Steel

L. American Public Transit Association (APTA):

1. APTA RT-EE-RP-001-02 Heavy-Duty Transportation System Escalator Design Guidelines

1.05 REGULATORY REQUIREMENTS

A. In addition to the foregoing referenced standards, the regulatory requirements which govern escalator work of these Specifications include the following codes and regulations:

B. California Code of Regulations (CCR):

1. CCR Title 8, Industrial Relations.

2. CCR Title 24, Part 2, California Building Code (CBC)

3. CCR Title 24, Part 3, California Electrical Code

C. California Occupational Safety and Health Act (CAL/OSHA)

D. In the event of a conflict between codes, regulations, these specifications or standards, the most stringent requirement as determined by the Engineer shall take precedence unless specifically addressed herein.

E. The requirement for CSA approval of electrical equipment as set forth in ANSI 17.5 will be waived by the District for any custom electrical equipment designed and manufactured specifically for this Contract.

1.06 DEFINITIONS

A. Heavy-duty escalator: An escalator designed specifically for transit system usage, which is substantially different from commercial units in the design of truss, machine, step, step chain, step chain tensioning device, step, brake, handrail drive and other components/equipment.

B. Working points: Points of intersection of step nosing lining and the horizontal of the top and bottom landing plates at finish elevation.

C. Special tools: Tools designed specifically for tasks associated with escalator inspections, maintenance, and repair, or those which are required for these tasks and are not readily available through normal purchasing channels.

D. Escalator support: These are the upper, lower and intermediate supports needed to support the total loads of the escalator.

E. Slip joints: A slip joint is a sliding joint required to support escalators in a transit system and high rise applications. Location shall be at bottom support areas or as indicated on the Contract Drawings.

F. Structural Rated Load: For the purpose of structural design, the rated load shall be considered to be not less than the weight of the escalator system plus the product of 320 pounds on each exposed step times the number of exposed steps.

G. Machinery Rated Load: For the purpose of driving machine, power transmission and braking calculations, the rated load shall be considered to be not less than:

Machinery rated load (pounds) = 6.0(W + 8)B (Approx. 320 lbs. per step)

Where: W = width of the step tread (inches), to the next whole inch.

B =√3 * Total Escalator Rise (feet)

H. Other definitions as per APTA RT-EE-RP-001-02.

1.07 QUALIFICATIONS

A. Manufacturer’s Qualifications: The escalator manufacturer shall have been a builder of heavy-duty transit type escalators regularly engaged in escalator building activity for at least the past five years. The design, engineering and manufacture of major escalator components such as truss, drive machine, steps, controllers, and safety devices shall be integrated and supplied by the escalator manufacturer of record, except where otherwise specified.

B. Installers Qualifications: The Escalator shall be installed by a California Certified Qualified Conveyance Company and supervised by a CCCM.

1.08 DESIGN AND CONSTRUCTION REQUIREMENTS

A. Escalators provided under the Contract shall be the product of the same Original Equipment Manufacturer (OEM). Design and construction requirements for the escalators shall meet at a minimum the requirements of the ASME A17.1 version in effect in California at the time of contract signing, except as specified herein, and as shown on the Contract Drawings.

B. Escalators shall be heavy-duty type (as defined in APTA RT-EE-RP-001-02), designed specifically for the operating, loading and environmental conditions encountered in extensively used, heavy-rail transit systems. Minimum design life shall be 25 years in use for 24 hours per day, seven days per week at the specified loading cycle.

C. The document APTA RT-EE-RP-001-02, Heavy-Duty Transportation System Escalator Design Guidelines forms part of this specification.

D. Escalators installed outdoors shall be designed to operate while exposed to the natural elements of weather, at all conditions of relative humidity, while exposed to airborne dust, debris, and corrosive elements at a dry bulb temperature range of plus 34 to plus 105 degrees Fahrenheit. Escalators installed outdoors shall have pit drainage systems to accommodate the drainage of rainwater. Pit heaters are not permitted.

E. Escalators installed indoors shall be designed to operate at a dry bulb temperature range of plus 34 to plus 120 degrees Fahrenheit. Escalators installed indoors shall have pit drainage systems to account for ground water and station wash-downs. Pit heaters are not permitted.

F. Escalators shall be designed and fabricated to fit within the well-way dimensions shown on the architectural drawings.

G. Escalators shall be designed to provide three flat steps at both the upper and lower ends.

H. The preferred location of the drive mechanism is either in the upper pit or in a room below the upper pit under the incline of the escalator as per the station design. Locating the drive mechanism in the step band is strongly discouraged.

I. The controller shall not be located within the escalator pit; it shall be located either in a room below the upper pit or below the truss incline, or in an exposed cabinet adjacent to the escalator at the top or bottom landing as per the station design. Where installed within an exposed cabinet location, cabinet shall be provided with lockable access doors, forced ventilation with filtered fans, and an internal heater. In such instances controller shall be designed to withstand high heat and humidity.

J. Escalators shall be designed with provisions for thermal expansion and contraction of complete escalator assemblies due to changing ambient conditions.

K. No wood products shall be permitted in the escalator system.

L. Each escalator shall be of 48-inch nominal width measured at centerline of handrails and be designed for an incline of 30 degrees from horizontal plane.

M. The drive mechanism, step drive unit assembly, steps, step linkage, comb plates, handrails, handrail drive units, and any parts subjected to wear or frequent removal shall be readily and easily removable and replaceable without requiring any modification or alteration of escalator structure, station structure, or equipment.

N. On parts of equipment subject to wear and requiring periodic replacement, provide key and seat, nut, screws, or other removable and replaceable type mechanical fasteners. Such replacements shall not diminish original structural integrity. Use of rivets or similar type fasteners requiring physical deformation during field positioning will not be permitted.

O. Gaps and running openings within structural design tolerances where the escalator structure meets the surface of the finished openings shall be properly closed by the use of polyurethane sealant as specified or other approved means installed in accordance with the manufacturers' instructions.

P. The equipment shall be quiet and smooth running and be capable of withstanding the operating conditions described herein.

Q. Surface irregularities, sharp edges, or protrusions in public and maintenance areas shall not be permitted.

R. Performance Requirements

1. Hours of escalator operation shall be considered as 24 hours per day, seven days per week.

2. Daily duty cycle shall be: three hours at 100 percent design load, six hours at 50 percent design load, and 15 hours at 25 percent design load.

3. Direction of travel shall be Bi-directional, up or down and reversible.

4. Speed: 100 feet per minute with four feet per minute maximum allowable speed variation under varying load conditions in either direction.

5. Vibration: Vibration level shall not exceed 0.4 inches per second as tested using a Bruel and Kjaer Model 2516 integrating vibration meter or equal. Readings will be taken throughout the travel of the exposed steps.

6. Variable Frequency Drive motor control a Hand/Auto/Off selector switch shall be provided to by-pass the variable frequency function.

7. Escalators must be capable of remote emergency stopping due to fire alarm or seismic alarm condition.

S. Seismic Design Criteria: The seismic design of the escalators, related supports and anchorages shall comply with CBC Section 1613, Earthquake Loads, and the referenced ASCE/SEI 7- Chapter 13, Seismic Design Requirements for Nonstructural Component, (Importance Factor, Ip=1.5). In addition, the Safety Requirement for Seismic Risk Zone 2 or Greater, (Importance Factor, I-1.25) and CCR Title 8 Section 3141.13(b), Seismic Requirements which references Section 3137(d) Seismic Requirements for Elevators, Escalators, and Moving Walks. The more stringent requirements among CBC, ASME A17.1, and CCR Title 8, Section 3141.13(b) shall govern.

T. Airborne Noise Criteria: Maximum airborne noise shall not exceed 65 dBA measured at a distance of 48 inches above any moving step throughout the length of escalator travel and the immediate surrounding public areas.

U. Fire Protection:

1. Contractor shall provide escalators constructed of non-combustible materials throughout as defined in ASTM E136, with the exception of handrails, handrail rollers, chain step wheels, and electrical equipment. Handrails shall have a flame spread rating of 76 to 200, when tested in accordance with ASTM E84.

2. Fire protection shall comply with requirements as defined in ASME A17.1 and NFPA 130. In case of conflict A17.1 takes precedence. Coordinate with fire protection systems specified in Divisions 20 and 21.

3. Wellways shall be a continuous concrete or a continuous minimum 8 gage, galvanized steel construction with an oil water drip pan with side walls at least three feet high installed within a minimum two-hour rated construction on all sides.

4. Wiring used throughout the escalator installation shall be low smoke and halogen-free.

5. PVC shall not be used anywhere in the escalator installation.

V. Clearances:

1. Bottom escalator pits: There shall be a minimum working space of 36 inches between the step guard and the end of the escalator truss or any component along the pit wall, whichever is less.

2. Upper escalator pits: For escalators with the controller located in the machine room, there shall be a minimum working space of 36 inches between the step guard and the end of the escalator truss or any electrical component along the head pit wall, whichever is less. For dual motor drive escalators there shall be a minimum working space of 36 inches between the outside face of the drive motor/machine and the end of the escalator truss or any electrical component along the head pit wall, whichever is less.

1.09 SUBMITTALS

A. General: Refer to Technical Specification Section 01 33 00, Submittal Procedures and Section 01 33 23, Shop Drawings, Product Data, and Samples for submittal requirements and procedures. All documentation shall have eight point or larger font, in English only.

B. Shop Drawings: Submit shop drawings and data including the following for the Engineer’s approval.

1. Fully dimensioned, U.S. standard, (i.e. feet and inches) layout in plan and elevation views indicating component locations, structural supports, access spaces, and points of entry.

2. Furnish reactions at the escalator truss supports and displacement of the escalator as determined from articles 1.08R and 2.04 herein to the Engineer.

3. Elevations and sections, manufacturing details of balustrades, deck, and skirt panels showing reinforcing jointing, anchorage, size, shape, and materials of each component, assembly details, finishes including push button fixtures, key switches, and required signage. Indicate direction of stainless steel directional grain.

4. Drawings showing the truss assembly, including materials, sizes and shapes of members, stanchions, reinforcing, connections, anchorages and supports, and attachment points for components. These drawings shall be stamped and signed by a currently licensed California Registered Civil or Structural Engineer.

5. Drawings for the truss, stanchion track system and supports, including drive chains and gear train; step chain or step links including chain pitch, step, and trailer wheels; reinforcing, jointing and anchorage; and size, shape, and materials of each component.

6. Drawings and technical data of the drive system, step drive system, handrail drive system, brake system.

7. Drawings and technical data for controller, and safety devices and switches.

8. Layout of electrical system including motor; control panel; disconnect switches; directional start and stop key switches; emergency stop switches and covers; light fixtures; receptacles, and control devices. Schematic diagrams including single line power diagram of the escalator system, control wiring diagram and sequence of operation, indicating interface connections with BART signal and control system. Contact count matrix to be included.

9. Provide complete schematics of all internal components and circuit boards, and wiring for external devices. Provide logic diagrams and application programming source code of controller. Show complete wiring diagrams with raceway types, sizes and conductor identification. Show nomenclature, full identification, and function of contacts. Documentation of software shall include programmer’s notes and comments. Identify any and all functions and components.

10. Step chain details for material, configuration, arrangement, and lubrication requirements.

11. Step nosing radii at upper and lower ends;

12. Step assembly including axle, step tread, rollers, frame, and riser.

13. Safety brush material, mounting method and profile.

14. Copy of the grade of steel and heat treatment records.

15. Records showing chain lengths, measured under tension.

16. Hardness and case depth test results on representative samples of step chain pin outside diameter and bushing inside diameter surfaces after finish-grinding.

17. Superficial hardness test results per ASTM E 18 shall be used on Rockwell C scale.

18. Knoop 500 gram microhardness test per ASTM E 384 shall be used to determine case depth.

19. Rigging plan.

20. Method of installation of the escalator.

C. Product Data:

1. Manufacturer's design data and material specifications for all replacement parts and equipment. Specifications shall include test methods required to verify compliance with specifications.

2. Lubricants, sealants, paints and any other potentially hazardous substances shall be submitted for the Engineer's review. The Contractor shall submit the necessary Material Safety Data Sheets.

D. Operation and Maintenance Manuals: Submit Operation and Maintenance manuals in accordance with Section 01 78 23, Operation and Maintenance Data.

1. Drawings, installation and maintenance instructions, and other data pertinent to the components used in the escalator systems, including detailed repair data for all components, including disassembly and assembly of drive system, handrail drive assembly, and track system, inspection/gauging/torque requirements, inspection and testing schedules, reassembly, testing methods and other related information. Manuals shall cover all mechanical and electrical components, operating panels, controls and indicators.

2. Bill of Materials. For each escalator, submit an Indented Bill of Materials. The Bill of Materials shall be a list of all assemblies, subassemblies, components and individual parts of the escalator. Each assembly shall be broken into subassemblies, which shall be in turn broken into components, subcomponents, or individual parts. There shall be a full definition of the item to a degree sufficient to allow a mechanic to place an order for a replacement part, i.e. description of the item, manufacturer part number, BART Stock Number and quantity required. Individual assemblies, subassemblies, components, subcomponents, or individual parts, common to one or more escalator shall have the same identification throughout the system. The Indented Bill of Materials shall be prepared using a commonly available database or worksheet program, to permit sort on any field: for example, it shall be possible with simple searches of the database to identify all escalators where a selected subassembly is used, to identify all subassemblies in which a selected part is used, or to obtain a total count of a selected component.

3. Sample copies of preventive maintenance procedures and charts.

4. Provide manuals and supporting software documentation for any specialized tools as applicable.

5. Trouble shooting techniques.

6. Complete detail drawings and wiring diagram of escalator fault finding device, source code and connection to annunciator panel.

7. Procedures for adjusting brake, handrail tension, handrail chain drive tension, step chain tension, track system, and mechanical components.

8. Instructions for removing floor plate, replacing comb components, removing and installing steps and interior panels.

9. Control and schematic electrical wiring diagrams and source code of controller, including wiring of safety devices to connections with remote indication and control panels for each escalator and group of escalators.

10. Electrical layout showing placement of lighting, light switches, receptacles, light fixtures, disconnect switches, and convenience outlets in machinery room, truss envelope, and pits.

11. Substantial completion will not be granted until the Operation and Maintenance manual is accepted and delivered and the training is complete.

E. Reliability and Maintainability Demonstration: Five copies of a reliability and maintainability demonstration report. Demonstrate and document compliance with reliability and maintainability requirements specified herein by means of (1) verifiable engineering analysis, (2) by static and dynamic testing, and (3) by analysis of field operational data. Submit the report 30 calendar Days after the completion of the escalator, and every 30 days thereafter. All reliability and maintainability documentation is subject to approval by the Engineer.

F. Failure Mode and Effects Analysis: Provide five copies of a Failure Mode and Effects Analysis for all escalator safety circuits and components, including but not limited to steps, brakes and step and axle rollers and any other components which could affect rider safety.

G. Structural Calculations: Submit structural details and calculations for the truss assembly as specified herein Article 2.04 and seismic design as specified herein Article 1.08. The structural details and calculations shall be stamped and signed by a currently licensed California Registered Civil or Structural Engineer.

H. Samples: Provide one sample of each of the following:

1. Handrail (two-foot section).
2. Step assembly including wheels, tread plate, and step demarcation.
3. Skirt panel: 12 inch by 12 inch minimum, including fasteners and trim.
4. Balustrade Panel: 12 inch by 12 inch minimum, including fasteners.
5. Comb plate and comb segment.
6. Demarcation light fixture.
7. Pit lighting fixture.
8. Safety switches.
9. Key switches.
10. Emergency Stop Button assembly with cover and alarm switch.
11. Two sets of six links including pin of the following chains:
    a. Main drive chain.
    b. Handrail drive chain.
    c. Step chain with rollers.
12. Anti-slide device.
13. Landing plate, full width.
14. Safety brush, 12 inches long.

I. Certification: For each lot or load of all chains and handrails delivered to the jobsite, furnish manufacturer’s affidavits or test reports of compliance or similar certification acceptable to the Engineer, certifying that the material complies with the escalator manufacturer’s specification requirements.

J. Submit a Training Development Plan for approval.

K. Submit a Test Program for approval with a test schedule and test procedure formats for every representative type of test that is to be scheduled. Refer to Field Quality Control specified herein for testing requirements.

L. Other drawing requirements and samples are specified in appropriate articles of this specification section.

M. Electrical Calculations: For each escalator, submit for approval:

1. Power system calculations signed by a currently licensed California Registered Professional Engineer for the main feeder circuit for operation at the Machinery Rated Load and for the escalator starting condition.

2. Electrical/Mechanical calculations for the sizing of driving machine, motor and brake.

N. Brake Calculations: For each escalator, submit detailed calculations for the brake, including calculations of braking distance and deceleration rate per prevailing ASME A17.1 for all loads from no load to the Machinery Rated Load, and for up and down directions.

O. Submit heat release calculations for machine room and controller enclosures.

P. Welders Certificates: Per AWS D.1.1 or Engineer approved equal.

Q. List of service prices for chargeable repairs.

R. As-built Drawings: Submit as-built drawings including the following for Engineer’s approval.

1. Truss stanchion

2. Track System and supports

3. Drive system

4. Step nosing radius upper and lower ends

5. Drive chains and gear train

6. Step chain or step links including chain pitch, step, and trailer wheels

7. Step assembly including axle, step tread, and frame and riser

8. Handrail system including profile, guides, and drive and tension device

9. Support details balustrade deck cover, interior panels, and skirt panels and moldings

10. Safety switches and operating devices

11. Motor and emergency brakes

12. Floor plates

13. Speed governor

14. Metal gauges

15. Radial vertical, and horizontal dimensions required for manufacturer and positions of lower and upper working points

16. Attachment of truss to structure

17. Major mechanical and electrical components within the truss

18. Drainage and electrical interfaces

19. Hand and finger guards

20. Ceiling intersection guards

21. Passenger instruction signs

22. Emergency stop button

23. Operating panel in upper and lower balustrades

1.10 FACTORY VISIT

A. Provide schedule of construction, assembly, and testing of major components at the factory or assembly plant.

B. The contractor shall arrange for the District's representatives to visit the factory where the escalator is being manufactured to test the operation. The travel costs for such visit will be paid by the District.

C. The escalator shall be tested at the factory with the controller to be shipped with the escalator. The District will observe the steps and chain in operation and test selected devices.

D. The installer shall not ship the escalator without the approval of the District after the conclusion of the factory visit.

E. The escalators shall not be shipped without the District's approval upon conclusion of the factory visit and tests.

1.11 SPARE PARTS

A. General: Spare Parts shall be provided in accordance with Section 01 78 44, Spare Parts and Maintenance Materials, as augmented by the following provisions.

B. Spare parts shall become the District's property and shall not be used by the Contractor for maintenance.

C. A “set” is the number of parts required per escalator.

D. Recommended Spare Parts List: Submit for approval a List of recommended spare parts necessary to support maintenance for a period of two years. The Engineer will review the List, assign a BART Stock Number to each item and return the List to the Contractor. The Contractor shall incorporate the BART Stock Number and resubmit the List, together with two additional sets of bar code labels to the District, prior to the acceptance of the escalator.

E. Required Spare Parts. The Contractor shall supply as a minimum the following spare parts, plus any additional parts identified by the approved Spare Part list.

1. Comb sections: Two Complete sets per escalator.

2. Steps: Ten complete steps per escalator.

3. One complete set of step chain for each size/type/model escalator supplied.

4. Handrail drive: One complete assembly for each escalator supplied (left and right) including, but not limited to, gears/chains, sprockets, and wheels.

5. Chain rollers: Two complete sets per axle per escalator.

6. Step rollers: Two complete sets per step per escalator.

7. Brakes: One complete set of all brake assemblies required for each size escalator supplied.

8. Demarcation fixture and ballast: Two complete sets per escalator.

9. Switches (micro/safety) and sensors: One complete set of all switches and sensors.

10. Fuses: Two of each size.

11. Printed circuit board or Programmable Logic controller (PLC) (Plug-in or hardwire); One for each type used.

12. Start switch/stop button assembly: One set per escalator.

F. Delivery: Notify the Engineer in writing 72 hours prior to any delivery. The notification shall identify the specific parts to be delivered. All spare parts shall be delivered no later than 30 calendar Days prior to the final acceptance of the escalator.

G. Spare parts shall be properly packaged so as to prevent damage during shipment and long term storage.

1.12 PERMITS

Refer to General Conditions Article 7.4, Permits and Licenses, for the Contractor's responsibility to obtain and pay for any and all necessary permits including and not limited to permit to complete and operating permits. The Contractor shall arrange and pay for inspections by governing authorities and obtain operating permits required until final completion of the contract. Contractor shall submit required drawings and design calculations to the State and a copy to the Engineer.

1.13 SPECIAL TOOLS

A. Deliver special wrenches, tools, and keys to the Engineer at the completion of each escalator, including but not limited to: all tooling required to attach a torque wrench to the drive machine used to accurately measure the brake torque, and a "Set" of tooling required to remove steps.

B. Deliver three complete sets of keys to operate each different type of key operated switch and lock.

C. Label each special wrench, tool, and key with an approved plastic or metal label tag. Labels shall be engraved to identify tool. For keys, provide each key and its tag on a small ring.

D. Deliver four hooks and/or T-Handles, required to remove floor plates.

1.14 MAINTENANCE

A. Maintenance Program: Within 90 Days after the Notice-To-Proceed, and prior to installation, Contractor shall submit a detailed maintenance program, showing functions to be performed and their schedule. The maintenance program shall include preventative maintenance, trouble call service and emergency repair service during the Maintenance Period. The maintenance program shall also include all work and materials needed to keep the equipment in perfect operating condition. Contractor shall coordinate and perform maintenance in a manner to result in minimum inconvenience to the public.

B. Maintenance Period:

1. Contractor shall perform preventive maintenance and any repairs on the escalator due to equipment failure for a period of 12 months after Substantial Completion is granted and the unit opened for public use. During the Maintenance Period, Contractor shall provide complete preventive and corrective maintenance on all components and assemblies of the escalator. At the end of the 12 months Maintenance Period, the District may extend the maintenance period by and additional two (2) years. If the District exercises this option, the Contractor will be compensated in accordance with the corresponding bid schedule line item. The District reserves the right to terminate the Maintenance Period at any time, upon giving 30 Days' notice to the Contractor. Contractor will not be relieved of maintenance until Relief from Maintenance is granted by the District.

2. Maintenance service shall not be subcontracted but shall be performed by or supervised by the Contractor's qualified CCCM personnel.

3. Maintenance shall include all labor and materials needed to achieve and maintain minimum 96 percent reliability for the equipment. Contractor shall coordinate and perform maintenance in a manner to result in minimum inconvenience to the public.

4. At the completion of the Maintenance Period, the equipment shall receive a final inspection performed jointly by the Contractor and the District representative. All discrepancies identified shall be corrected at no additional cost to the District. The term of the Maintenance Period shall be extended to provide sufficient time required to clear all identified discrepancies as approved by the Engineer at no additional cost to the District.

5. The maintenance service will not be required to cover adjustments, repairs, or replacement parts due to misuse, abuse, or vandalism.

6. The Contractor shall maintain local inventory of all wearing parts of the escalator system. Only genuine OEM parts and supplies used in manufacturer and installation of the original equipment shall be provided.

7. Contractor shall obtain written approval from the BART administrator prior to replacing parts.

8. Contractor shall provide and maintain up-to-date complete list of personnel who access the District assets. The list shall include names and 24-hour contact information, including telephone numbers.

C. Trouble calls during maintenance period

1. For any trouble calls, the District will notify the Contractor of the incident. The Contractor shall be on site within four hours. The Contractor shall notify the designated BART Elevator/Escalator Maintenance representative upon arrival to the site, and check out upon completion of the trouble call. BART personnel may observe the repairs or adjustments made by the Contractor's personnel.

D. Escalator Access:

1. For routine maintenance, the Contractor shall request access to the escalator and coordinate access with the BART elevator/escalator maintenance department representative.

E. Work Hours for Maintenance:

1. Repairs required to return equipment to service shall be accomplished as soon as possible during revenue and non-revenue hours.

2. Routine maintenance, non-urgent repairs, and warranty work shall be performed on no more than one escalator at a time at a station. Routine maintenance shall not be performed during revenue peak hours. Routine maintenance may also be performed during non-revenue hours. Refer to the Contract Specifications for a definition of revenue peak hours and non-revenue hours for the station.

F. Inspection during the Maintenance Period:

1. The Contractor shall perform systematic inspection every two weeks, which shall include adjustment and lubrication of escalator equipment as required by the manufacturer. Replace defective parts with new parts of same manufacture as required.

2. There will be an annual permit inspection scheduled by and at the expense of the District.

3. BART will monitor Contractor's work by whatever means are deemed necessary, including employing others to inspect and/or test the equipment condition and the maintenance work quality.

G. Escalator Shutdowns:

1. Should an escalator become inoperative, the Contractor's service representative shall physically attend to the escalator within four hours of notification of a failure. If the failure occurs after 8:00 PM, the service representative shall be on-site no later than 7:30 AM the following Day. This schedule shall apply seven days per week, 52 weeks per year. The escalator shall be returned to service as quickly as possible.

2. Should there be a failure to comply with the above response time requirements a penalty of $500 shall be assessed for each hour delay.

H. Final Service and Inspection:

1. Two weeks before expiration of the Maintenance Period, the equipment shall be lubricated, fully serviced, adjusted to the standards designated herein and safety devices shall be checked; Contractor shall re-lamp the escalator demarcation light fixture and the pit light fixtures. A complete inspection will be performed jointly by the Engineer or District representative and Contractor's representative. A comb impact test and a no- load brake tests in accordance with Article 3.03, Field Quality Control, herein shall be performed by the Contractor. If these tests demonstrate any non-compliance with the specifications, the Contractor shall perform the full battery of brake tests until the escalator is in full compliance. Each test shall be approved by the Engineer.

I. Contractor will not be responsible for cleaning and repair of balustrades, cladding, or decking, unless repair is necessary and performed due to defective materials or improper installation. Contractor shall be responsible for cleaning of oil and grease residue as well as any debris resulting from their maintenance or repair activity.

J. The contractor's technicians responding to trouble calls or performing Preventive Maintenance shall contact the designated BART Elevator/Escalator Maintenance representative and provide the following information: worker's name, date, arrival time, total time spent on site, parts inspected, adjustments made, parts replaced, and detailed description of the work done.

K. A work log on each escalator shall be maintained at the escalator location, providing information on date and time of the visit, worker's name, date, arrival time, total time spent, parts inspected, adjustments made, parts replaced, and detailed description of the work done. The work logs will be regularly reviewed by the Engineer.

L. Chargeable Repairs: Contractor will not be responsible for the cost associated with trouble calls that are due to misuse, or accidents, or are otherwise not caused by the Contractor. Calls which result in adjustment of safety devices not accessible to the public will not be reimbursed. Contractor shall submit all documentation necessary to prove that a particular trouble call should be a Chargeable Repair. Contractor shall submit all documentation necessary to justify the direct costs incurred for chargeable repairs and detail charges in accordance with the schedule of service prices submitted and approved by the Engineer prior to the start of the maintenance period.

1.15 RELIABILITY

A. Definitions:

1. Break-in Period: The initial period of operation of the escalator. There shall be only one break-in period for the escalator, regardless of maintenance, unless a modification or other major work done has been performed on the escalator, during, or after the break-in period.

2. Failure: An incident which is corrected by replacing a part, resetting the unit, or making an adjustment. Exceptions to failure are conditions of misuse, vandalism, accidents or negligence not caused by the Contractor.

3. Incident: An incident is any escalator stoppage, regardless of cause.

4. Pattern Failures: The occurrence of multiple independent failures of the same primary replaceable item or adjustment in identical or equivalent applications.

5. Reliability Demonstration Test (RDT): A test to determine a reliability-associated parameter, such as available operating time, within defined statistical risks or with a specific statistical confidence.

B. Requirements:

1. The Break-in Period shall begin after the installer has satisfactorily completed the escalator installation, obtained State operating permits and the Engineer has performed and approved substantial inspection of the escalator. The escalator shall be barricaded and operated continuously under no load condition for a minimum of 48 hours. Upon a continuous, 48-hour operation without incident, the barricades may be removed and the escalator may be put into service to be used by the public.

2. After the Break-in Period, the Reliability Demonstration Test (RDT) shall begin. The escalator shall operate up to full load under normal modes of operation in either direction and be able to provide minimum 96 percent reliability as determined by the following formula:

   Percent Reliability = T/A

   T = Actual aggregate operation time for the escalator. Downtime for scheduled preventative maintenance and incidents, which are not failures, shall not be deducted from the aggregate operation time.

   A = Aggregate revenue operating time of the respective BART station, nominally 20 hours per day.

3. Contractor shall take corrective action to eliminate pattern failures, regardless of total operating time accumulated. The Contractor shall notify the District's Engineer or designated elevator/escalator maintenance representative that an escalator undergoing corrective maintenance is ready to be returned to service to ensure appropriate time tracking for the purpose of accurately tracking the reliability percentage by using the formula above. Failure by the Contractor to report "returned to service" will result in lower reliability performance and will remain the responsibility of the Contractor.

C. The Contractor shall:

1. Collect the data and document the results of the RDT, perform all calculations, and issue the results.

2. Review all failure incident reports to ensure that only pertinent failures are included in the test results.

3. Review the data with District at interim stages of the RDT and at the final stage, prior to issuing the results.

D. If the District determines that the RDT has fallen below the 96 percent goal for any consecutive 30 Day period, the Maintenance fee due to the Contractor for that 30 Day pay period shall be reduced by the following formula:

   A = MF * Percent Reliability

   A = Amount due to Contractor

   MF = Monthly Maintenance Fee for one escalator.

   Percent Reliability = As calculated above.

Prepare and submit reliability and maintainability report per Article 1.09.E.

1.16 REPORTING

A. The Contractor shall submit to the BART administrator monthly service records, including repair work reports, call out reports, and semi-annual inspection reports for each escalator. The reports shall contain the details of each maintenance and repair activity including at a minimum the following:

1. Equipment ID.
2. Date.
3. Time on site.
4. Location.
5. Crew size.
6. Work duration.
7. Description of the work performed.
8. Parts replaced.
9. Cause of the shutdown and the resolution of the same.

B. The records are required to be submitted with the invoice package and are required for payment processing.

PART 2 – PRODUCTS

2.01 GENERAL

A. Each escalator shall be a self-contained, heavy-duty transit unit as defined by APTA RT-EE-RP-001-02 consisting of truss, tracks, step drive units, steps, step chains, comb plates, handrails, driving machine, controller, safety devices, balustrades, cladding and all other parts required to provide a complete operating installation. The design and method of installation of each escalator shall be such that each will operate within the tolerances specified herein. Installation shall allow items in machine space to be removed with portable hoist or other approved means for replacement or repair.

B. Each escalator assembly shall meet the requirements of CCR Title 8, CCR Title 24, Part 2 and 3, ASME A17.1, A17.2, ANSI A17.5 and NFPA 70 and 101.

C. Each escalator shall be of the cleat step, reversible type with full semicircular extended newels and handrails. Each escalator shall be capable of operating and stopping under full load condition in either direction for ascending or descending transportation service.

D. Weatherproofing: All ferrous, non-stainless steel metal surfaces shall be hot-dipped galvanized, spray on zinc coated, or powder coated as approved by the Engineer. Machined and operational areas shall be protected from corrosion by applying a rust preventative compound, plastic foils, oil or grease. Electrical enclosures shall be NEMA 4 or 4X, stainless steel enclosures and penetrations, raceways and wiring shall be waterproof. Wiring shall be in galvanized rigid minimum three fourths of an inch steel conduit along the incline portion of the truss and within the upper and lower pit spaces except where otherwise noted. Flexible conduit (NEMA 4 rated and provided with an internal galvanized flex core with a liquid tight protective outer cover) can be used to obtain the necessary bending radii to get to switches and sensors. Decking, balustrades, and cladding shall have smooth and tight fitting seams to prevent rainwater from entering the escalator truss.

E. Lubrication System Requirements

1. Parts, other than sealed bearings, requiring lubrication shall be designed for an automatic or remote lubricating system. The lubrication system shall operate only when the escalator is running and the amount of lubrication shall be fully adjustable. A reservoir shall be provided with a low oil signal to the controller, and a minimum capacity sufficient for one month of operation without refill.

2. The lubrication system shall be positive acting and located in the escalator pit to allow for easy access.

3. Reservoir level indications shall be provided and visible where lubricants are contained within housings, supply tanks, and large filler cups.

4. Contractor shall furnish and mount near the lubricating system in the escalator pit, a framed lubrication chart for each escalator. The chart shall show the location of each lubrication point, type of lubricant to be used, and the frequency of lubrication.

5. All tubing shall be supported to truss structural members using clamps or other approved support method.

F. Bearings

1. Bearings shall be ball or roller bearings rated for severe, heavy-duty service, 200,000 hours L10 life.

2. Bearings shall be pre-lubricated by the bearing manufacturer for the life of the bearing.

3. Bearing manufacturer shall be ISO 9000 series certified.

G. Oil collector chutes and collection trays shall be fabricated galvanized or stainless steel, shall be watertight and shall be free of obstructions for ease of cleaning.

H. Fasteners – Fasteners shall conform to the following:

1. Fasteners exposed to view to the public shall be stainless steel as specified herein.

2. Truss structure bolts shall be galvanized steel as specified herein.

3. Fasteners required to be removed for routine maintenance as defined by the manufacturer's own maintenance manual shall be stainless steel as specified herein. At a minimum, the following fasteners shall be stainless steel:

   a. Floor plate supporting hardware.

   b. Handrail tension device, mounting and adjusting hardware; friction belt roller mounting and spring plate adjusting mountings; handrail drive shaft flanged pillow block mountings and adjustment slotted fastenings, and all adjusting hardware.

   c. Handrail support roller mountings.

   d. Mounting hardware for the service brake solenoid, brake band, all switches mounted on the end of the motor-mechanical blocking device switch and flywheel mounting hardware.

   e. Safety brake solenoid mounting hardware.

   f. Slack drive chain switch mounting hardware.

   g. Safety switch and proximity device mounting hardware.

   h. Mountings, fastenings, and adjusting hardware on the comb plate and comb impact devices.

   i. Step band guard mountings.

   j. Handrail drive chain tensioning assembly, adjusting fasteners, and mounting fasteners.

   k. Handrail rupture safety device mountings.

   l. Handrail entry fastenings for inner and outer plates and handrail rubber collar mountings.

   m. Skirt panel mounting fasteners, splice brackets, skirt switch mounting bracket fasteners.

   n. Handrail decking joints, mountings, and fastenings.

   o. Balustrade panel studs and trim mountings.

   p. Electrical junction boxes within the pits and truss, and the mounting hardware for anything housed within these boxes such as DIN rail mountings and switch and device fastenings.

4. Other fasteners shall be equal to or of greater corrosion resistance than the most corrosion resistant metals being fastened.

2.02 MATERIALS

A. Sheet Steel: ASTM A1008/A1008M, uncoated, pickled.

B. Sound Deadener: Vibradamp Corporation's No. 111, 3M's Coating ED-1000, Presstite's No. 105A, or equal; asphaltic based compound for spray application; black.

C. Stainless Steel: Type 316, unless Type 316 does not exist for a particular item or shape, then Type 304, NAAMM AMP 503 No. 4 finish where exposed.

D. Structural Steel: Conform to Section 05 12 00, Structural Steel Framing.

E. Fasteners:

1. Externally threaded steel fasteners shall conform to SAE J429, Grade 5.

2. Steel Nuts (other than locknuts) shall conform to SAE J995, Grade 5 or ASTM A563 Grade B.

3. Locknuts shall conform to IFI 100/107 "Prevailing-Torque Type Steel Hex and Hex Flange Nuts," Grades B. Also, non-metallic (nylon) top insert locknuts conforming to ASTM B18.16.6-2008 grades NE5 are acceptable.

4. Stainless steel externally threaded fasteners shall conform to ASTM F593. Stainless steel nuts shall conform to ASTM F594. Stainless steel material shall be Group 1, Alloy 304 or equal, condition CW.

F. Aluminum: ASTM B211, B221 and B308/B308M. 6061 or alloy and temper best suited for anodizing finish specified.

G. Aluminum Sheet or Plate: ASTM B209, 6061 alloy, T651 temper.

2.03 FINISHES

A. Exposed-to-View Surfaces:

1. Sheet Steel:

a. Shop Prime: Clean of foreign substances and apply one coat of zinc chromatic or similar primer compatible with finish paint specified.

b. Finish Paint: Three coats enamel in accordance with paint schedule; sand each coat smooth; color as selected by the Engineer.

c. Powder coating is allowed in lieu of primer and paint and shall be tested per ASTM B117 and D2794.

2. Stainless Steel: Plain: Satin directional grain, NAAMM AMP No. 4 finish, #180 grit or finer, unless otherwise specified. Sanding medium shall not deposit particles in the grain that are capable of rusting.

B. Paint and Corrosion Protection: The escalator shall have the following minimum corrosion protection:

1. Ferrous metal parts of the escalator, including cast metal parts such as gear housings, chain sprockets, and return station sprockets that are not stainless steel or galvanized, shall be prepared in accordance with SSPC SP-6 and shall be primed with a rust-inhibitive primer and painted or otherwise protected as approved by the Engineer. Paint finish coats shall be as follows:

    a. Two heavy-duty gloss enamel, minimum two mil (dry film thickness) each coat.

2. After welding, the truss shall be hot-dipped galvanized with a coating in accordance with ASTM A123, or coated with 100 percent zinc thermal spray complying with AWS C 2.23M/C2.23, NACE No. 12, SSPC-CS 23.00 and applied in accordance with ANSI/AWS National Standard for application of thermal coatings.

3. Galvanizing

    a. Sheet Steel thicker than 10 gage; ASTM A653, as applicable. Coating designation G185.

    b. Other galvanizing: ASTM A123, A153 or A385, as applicable.

    c. Galvanizing Touch-up: Zinc coating: MIL-P-21035.

4. Powder coating is allowed in lieu of primer and paint and shall be tested per ASTM B117 and D2794.

C. Steel Fasteners. Except for stainless steel, steel fasteners shall be zinc plated per ASTM B633 Fe/Zn, Class 5, Type III, colorless chromate treatment.

2.04 TRUSSES

A. General

1. The trusses shall span the distance between the support points as indicated. The working points as indicated shall not be moved except as approved by the Engineer.

2. Trusses shall be sufficient width to accommodate the width of the finished escalator.

3. Trusses shall be designed to rest on the available truss supports, and/or existing supports in each facility.

4. Trusses shall be of ample strength to maintain alignment of tracks and moving parts, and so designed that they shall safely retain steps and running gear, and in case of failure of track systems, retain step mechanism within guides and envelope of the truss.

5. The truss shall be designed to applicable AISC standards referenced in Section 05 12 00, Structural Steel Framing to support the Structural Rated Load.

6. The vertical deflection of the loaded trusses shall not exceed one one-thousandths (1/1000) of the free supporting distance of not less than 50 feet. Deflection shall be measured at the midpoint between the support points from the position of the unloaded truss to the position of the truss with the fully installed escalator loaded at the Structural Rated Load.

7. Truss material and fabrication shall conform to Section 05 12 00, Structural Steel Framing, and Section 05 05 22, Metal Welding.

8. Holes for attaching components shall be drilled or punched prior to galvanizing truss.

B. Field Modifications, Connections, and Shims.

1. Field splices shall be rigid non-deforming, and shall maintain alignment.

2. Field modification by burning shall not be permitted.

3. Field modification shall not compromise paint and corrosion protection.

4. Shims shall be stainless steel, Type 316.

5. Support shims shall not exceed 2 inches.

C. Structural Requirements:

1. The installer shall provide escalator truss mounting angles and intermediate truss supports with attachments, sized as required to install escalators into well-way structural support system shown on the Contract Drawings.

2. Escalator intermediate support points shall be provided by the installer where indicated on Contract Drawings. Reaction loads, and calculations shall be signed by a Civil or Structural Engineer, licensed in the state of California, and submitted by the escalator installer for approval by the Engineer.

3. Seismic calculations shall be based on the APTA design loadings in this document.

2.05 DRIP PANS

A. Provide for each escalator, a drip pan of sufficient size to collect oil and grease from step linkage, rainwater, and all forms of loose debris that may be deposited into the escalator truss. The drip pan sidewalls shall have a minimum height of three inches at the top pit and incline section and a minimum height of four inches at the bottom pit. At the upper section of the truss, the drip pan shall be sloped so that all liquids collected drain towards the lower section of the truss. At the lower section of the truss, the drip pan shall be constructed so that the liquids collected drain from anywhere in the truss towards a drain in the drip pan. Drip pan construction shall

prevent oil from leaking below the truss. The drip pan shall flow into a catch basin under the truss that is connected to the industrial waste line of the station or as indicated on the Contract Drawings.

B. Drip pan shall be of watertight, minimum eight gauge, galvanized sheet steel construction over the entire length and width of the truss and under the machine and pit spaces. All joints between the sheets making up the drip pan shall be sealed over the entire length of the joint. Pan shall be hot-dipped galvanized after all welding, drilling, and tapping have been completed. 100 percent zinc thermal coating per AWS C 2.23 M/C 2.23, NACE No. 12, SSPC-CS 23.00 is also acceptable as approved by the Engineer. The drip pan shall be capable of supporting 150 pounds per square foot and 500 pounds concentrated load. Drip pan shall have a removable drain plug located at the lowest end. Drip pan shall be mounted within the truss members and shall be free of obstructions to permit flow of liquids and small debris and to facilitate clean up. Brackets or other obstructions shall not be fastened to the inside of the drip pan.

C. An access hatch, 18 inches in diameter, shall be located in the drip pan at the lower landing, directly above the escalator pit drain for the purpose of cleaning the drain catch basin. The hatch shall be of same material and shall be designed to support 150 pounds per square foot.

D. Prevent the splatter of chain or gear oil beyond the escalator truss and drip pan.

E. Any water intrusion at the top and bottom of the escalator, shall be prevented from entering the well-way and directed to drain into the truss drip pan.

2.06 STEP DRIVE UNITS

A. The step drive unit shall be designed for heavy-duty transit escalator service and be mounted and supported within the truss envelope at the upper end.

B. Escalator drive equipment shall be readily accessible for inspection, servicing, and replacing of equipment.

C. Carriage Requirements: Carriage for tensioning step chain shall move on tracks. Such movement shall be accomplished by use of precision ground rollers or slides and horizontal guides to prevent skewing while adjusting carriage.

2.07 TRACKS

A. Design and fabrication of tracks shall retain steps and running gear safely under load requirements and at the highest design speeds specified.

B. Contractor shall assemble and secure sections of track together for easy removal and replacement of defective sections. The system shall be adjustable, and welding of the tracks is not acceptable.

C. Design of the mechanical components shall provide for easy installation and removal without the dismantling of parts of the structure.

D. Tracks shall be properly supported on trusses to provide correct alignment and smooth transition to return stations. The rolling surface of the track shall be a minimum thickness of 0.13 inch.

E. The track system shall be smooth for continuous support of the chain wheels from sprocket to sprocket. The transition between incline and upper landing level shall be accomplished by a curved track system with a minimum of 102 inches radius; the transition between incline and lower landing level shall have a minimum of 79 inches radius.

F. The guiding system for the step chains and step wheels shall be of hot-dipped galvanized steel profiles with smooth and even running surfaces, and with the joints cut diagonally to the running direction.

G. A second, continuous guiding profile shall be provided above the step chain rollers so that the step chains are positively guided in the area of the escalator open to passengers.

2.08 DRIVING MACHINE AND MOTOR

A. Machine shall be readily accessible without use of special tools. The motor shall be flange mounted directly to the driving mechanism. Worm or helical gears may be employed.

B. Motor shall be fan cooled and have a service factor of 1.15 and have insulation group B. Motor shall be a variable frequency drive (VFD), AC induction motor and shall operate at 480 Volts, 3 phase, 60 Hertz power. Motor shall be rated for minimum 90 starts per hour, and be designed and built specifically for escalator applications.

C. V-belt drives are not acceptable. If chain drives are used, they shall be protected against dirt and water by sealed housings, and shall have an automatic lubricating device and an adjustable means of taking up any slack in the chain.

D. The driving machine shall be designed to operate continuously for the Machinery Rated Load.

E. Motor encoders and speed sensors shall be capable of bypassing or disabling, forced underspeed, overspeed, and reversal. Any encoder, speed sensor etc. shall be of the heavy-duty type, and covered as approved by the Engineer.

F. Gear Box Requirements:

1. Gear bearings shall be rated with an ABMA L10 life of 200,000 hours and housed in an oil tight, dust proof case. The case shall provide a convenient method of draining the oil.

2. Use synthetic lubricants, subject to Engineer approval.

3. Rotating parts shall be provided with the means for lubrication and retention of lubricants.

4. Sealing bearing shall be used.

5. Exposed, moving, drive elements shall be protected by metal housing, which shall provide access for lubrication of components.

6. Provide a low oil sensor to prohibit starting of the escalator on automatic operation with low oil in the gearcase.

G. Head shaft bearings shall be rated with an ABMA L10-life of 200.000 hours.

H. Exposed gearing, sprockets, and chains shall be covered with guards. Side panels of guards shall be in sections of convenient size and removable for purposes of inspection and maintenance.

2.09 CONTROLLER AND WIRING

A. The escalator control equipment shall contain diagnostic capabilities as required for the ease of complete maintenance. The diagnostic system shall be an integral part if the controller and provide user-friendly interaction between the service person and the controls. All such systems shall be free from decaying circuits that must be periodically reprogrammed by the manufacturer.

B. The controller shall be mounted in stainless steel, NEMA 4X cabinets with strip heaters and labeled terminal strips. Enclosure shall utilize continuous stainless steel hinge and two-point fastening mechanism.

C. The main controller shall use a programmable logic controller (PLC) to control and monitor the status of the escalator. The PLC shall be designed to communicate with escalator parts over an Ethernet port or serial port(s). In addition, it may also have a dedicated serial port for programming or configuring purposes.

D. The PLC racks shall provide space for two (2) future single-slot modules.

E. The PLC shall store the last 99 safety device faults, accessible via laptop connection, panel view, or remote communications.

F. Provide a copy of all working programs on approved computer medium as well as a printed program listing.

G. The controller of an escalator shall contain at least the following devices:

1. Lockable main switch thermal and magnetic motor protection starter for up and down travel, hour counter, auxiliary contractors, phase failure device, phase sequence monitor, and ground fault monitor.

2. The controller cabinet shall contain a permanently mounted full color view panel capable of providing fault and operating data. The indication shall be locked automatically. Reset shall be done by a separate switch installed in the controller. The emergency stop shall not be locked.

3. Terminals shall have identification markings and cables shall be provided with cable markers.

4. The controller may be equipped a full time, regenerative, VFD drive capable of full speed control for maintenance and future “sleep mode” operation.

5. Relays shall be provided with visual indication that they are energized.

6. Controller shall be capable of operating the escalator in Variable Rated Speed Operation as per ASME A17.1-2010 requirement 6.1.4.1.1 regardless of the ASME A17.1 Code in effect.

7. A non-reset, minimum five-digit, run time meter shall be provided with the controller to measure whole hours escalator is in operation.

H. Wiring shall be minimum No. 18 AWG stranded, color coded, and permanently identified with embossed tubing sleeves to match controller schematics at all terminations. Wiring shall be low-smoke and halogen-free. A maximum of three wires shall be terminated at any screw type terminal. Wiring jumpers, taps and multiple wire connections shall be located on a terminal; tee taps, wire nuts or mid conductor splices are not permitted. All controls shall operate at 120 Volts or lower, AC or DC. Control power shall be obtained from integral dry type control transformers. Primary and secondary fuses shall be provided with load side indicating neon lamps.

I. Raceways in truss between components shall use rigid galvanized steel conduit with threaded or compression fittings. When used, flexible raceways shall utilize liquid-tight flexible metal conduit and compression type fittings. Flexible raceways shall not exceed six feet in length. Boxes shall be NEMA 4X stainless steel. Water tight, gasketed hubs shall be used for all raceway, entries to cabinets, boxes and controller.

1. Wiring external to controller including switches and control wires shall utilize at least No. 18 AWG copper stranded machine tool type, moisture, heat and oil resistant thermoplastic insulated conductors. Terminations at devices and terminals shall utilize insulated type crimp connectors. For all crimped connections, crimper used shall be Panduit CT-550 or equal. Anti-corrosion protection shall be provided for all connectors using Thomas and Betts “KOPR-Shield” CP-16 or equal. Terminals shall be identified with wire numbers that correspond to wiring diagrams. Wiring shall be laced and tied at terminal blocks. Conductors shall be identified with embossed tubing sleeves at each terminal. Terminations shall be made within boxes at terminal strips.

2. Wiring shall be tested by means of 500 Volt megger prior to connection to safety and control devices.

3. Control wiring shall be color coded by function to assist in troubleshooting and maintenance.

J. Main power feed to controller shall be a 480 Volt, three phase, dedicated circuit. If escalator is being installed in an existing facility and existing circuit breaker(s) are insufficient for new escalator, then the Contractor shall furnish and install new, appropriately sized circuit breaker(s). Contractor shall provide the necessary cabling and any conduit modifications from the switchgear cabinet to the new escalator controller at no additional cost to the District. New conduit shall be concealed within structure except as otherwise indicated on the Contract Drawings.

K. Remote Control Inspection Station:

1. Provide a remote control inspection station consisting of a portable switch box, extension cord, and plug-in cap for each escalator to allow operation of the escalator by remote control during periods of inspection and service.

2. The remote control inspection station shall include an emergency stop switch (maintained-contact selector switch), and “up” direction push button (momentary contact only when button is held down) and a “down” direction push button (momentary contact) housed in a stainless steel enclosure and connected to a 10 foot “Tyrex” cord (number of conductors as required) with multi-conductor screw cap and matching receptacle, suitable for use in corrosive area.

3. Two receptacles with tethered or hinged weatherproof caps, one at each end of the escalator, shall be provided in the pit area for the attachment of the remote control inspection control station. These receptacles shall be of a common ready available national brand manufacture and designed such that the escalator will not initiate normal operation unless caps are in place.

4. When the remote control inspection station is plugged into either receptacle all normal operating devices, including all regular and automatic control switches, shall become inoperative and full control of the escalator shall be transferred to the remote control inspection station. The operating speed of the escalator shall automatically be reduced to the maintenance mode speed. Control shall be returned to the normal operating devices when the remote control inspection station is removed from the receptacle and the receptacle cap is in-place. All safety devices except missing step devices, handrail speed sensors and speed encoders shall remain effective during the maintenance mode.

L. Fault Indicating Device:

1. Provide a fault indicating device in the front panel of the controller that shall visually indicate and identify the actuation of each and every safety device causing escalator shutdown and shall cause the indication to remain until the fault is cleared by maintenance personnel or automatic reset.

2. Provide an identical display and reset button in the upper right newel of the escalator, or at a location to be determined by the Engineer. The local display shall be concealed behind a lockable door. The type of key will be assigned by the Engineer.

3. The fault indication device shall provide diagnostic capabilities including the following information:

    a. Historical data storage in ASCII text of at least 100 events that records escalator identification, date, time and cause of any and all escalator stoppages and faults. Historical data shall be printable by downloading to laptop computers.

    b. Drive motor over temperature.

    c. Braking distance with date and time stamp for each stoppage, manual or automatic. Measurements shall be expressed in inches and accurate to 0.1 inch.

    d. Operating status of escalator (ready to run, running, reset required, or maintenance mode).

    e. Operating direction of escalator.

4. Event data shall be retained if the power to the controller should fail.

M. The Contractor shall provide one notebook style computer and the necessary software to assist in the programming, setup, and troubleshooting of the escalator controller. The computer software shall be able to extract, view, store, and print the event reports from the controller and provide access to any other available trouble shooting information the controller may provide. The computer shall have the latest processor and operating system compatible with the escalator controller and shall have the ability to update all software.

N. Foreign Voltage Relay: Provide one multi-pole, 600 Volt Class for isolation of foreign voltage conductors entering the controller to safely isolate electrical sources. Examples of foreign voltages are the fire alarm shutdown, external directional signs, seismic switch, rolling grille, and malfunction alarm to station agent’s booth. Coil of relay shall be de-energized when main disconnect is open. Relay shall be located in separate NEMA 4X stainless steel box and shall be labeled “Foreign Voltage Relay” with an engraved nameplate.

O. The escalator controller shall interface with the station fire alarm system. In the event of station fire alarm signal, the escalator emergency stop alarm shall be activated for at least 15 but not more than 20 seconds, at which time the power to the driving machine motor shall be interrupted and the brake applied.

P. The escalator controller shall interface with the station seismic sensor or a dedicated escalator seismic switch located in machine room, as approved by the engineer. In the event of seismic event, the power to the driving machine motor shall be interrupted and the brake applied immediately and the escalator emergency stop alarm shall be activated immediately and operate for at least 15 seconds.

Q. The escalator controller shall interface with the associated, station entrance, security grill where present. Escalator shall shut down when grill is lowered.

R. The controller shall provide the necessary relay contacts to control the station ceiling directional signs, including during fire alarm activation.

S. The escalator controller shall provide the signal to report any failures or out of service conditions to a District's remote monitoring system. Additional signals shall be provided to indicate operating modes (running up, running down stopped, stopped with a fault) display in the station agent's booth.

1. The escalator controller shall also provide discrete, normally open contacts or dedicated PLC output signals to each of the safety devices within the escalator to interface with the SCADA system. Other safety devices not listed shall be combined with other faults as determined by the Engineer.

   a. Emergency Stop – Top.

   b. Emergency Stop – Bottom.

   c. Handrail Inlet – Top (left and right).

   d. Handrail Inlet – Bottom (left and right).

   e. Skirt Switches – Top (left and right).

   f. Skirt Switches – Bottom (left and right).

   g. Comb impact – Top (left and right).

   h. Comb impact – Bottom (left and right).

   i. Missing Step – Top.

   j. Missing Step – Bottom.

   k. Step Sag Switch – Top.

   l. Step Sag Switch – Bottom.

   m. Step Upthrust – Left and Right.

   n. Starting Fault – (reverse phasing, anti-reversal switch).

   o. Brake watchdog (brake pick and brake wear).

   p. Communication fault.

   q. Miscellaneous – Pit Switches, broken drive chain switch, overload, governor.

   r. Carriage tension switch – Left and Right.

   s. Handrail speed – Left and Right.

   t. External Safeties – Fire alarm shutdown.

   u. "Mechanic On-Site" switch. This switch is activated by opening Newel display swing door, or the controller door, or when controller is on "Manual". When activated, the event is automatically entered into controller history log, and into BART SCADA system.

   v. Running up. This signal is intended for display in the station agent's booth.

   w. Running down. This signal is intended for display in the station agent's booth.

x. Stop. This signal is intended for display in the station agent's booth.

y. Stop with a fault. This signal is intended for display in the station agent's booth.

2. Besides an Ethernet port (if any, as described in 2.09-C) to control/monitor escalator devices, the programmable logic controller (PLC) shall have another Ethernet port to communicate with the SCADA and NTP server. The PLC shall support automation protocols such as Distributed Network Protocol over TCP (currently DNP3), Ethernet/IP (ODVA CIP), Modbus/TCP, or BART Communication Protocol (BCP).

3. Alternatively, instead of the direct Ethernet connection to SCADA as mentioned above, contractor may provide District-approved remote input and output modules which are compatible with the station SCADA system.

4. A separate Ethernet communications path will be provided from the train control room BARTnet interface cabinet to each escalator controller to provide the ability to time synchronize the controller with BART Network Time service (Network Time Protocol – NTP). An Ethernet connection on the escalator controller will be provided. The NTP server service to drive this connection will be BART's responsibility. The escalator controller will provide an NTP software client compatible with NTP Version 3 Specification (RFC 1305) and be capable of operating in NTP broadcast-client mode.

T. Controller devices shall be labeled corresponding with identification shown on wiring diagrams. Labeling medium shall be either indelible stamped ink or engraved labels.

U. Switches and indications mounted on the controller enclosure's exterior shall be labeled with laminated engraved white on black five sixteenths of an inch character permanently mounted nameplates.

V. Section 20 70 26, Common Materials and Methods for Electrical Systems, shall govern electrical materials and methods not covered in this Section.

W. Controller shall have circuitry terminals to disable any and all speed and detector sensors for testing and trouble shooting.

2.10 SAFETY DEVICES AND SWITCHES

A. Key Switches:

1. Escalators shall have key operated switches, accessible at both upper and lower landings, located on the exterior deck above the newel base. Alternate locations may be used subject to approval by the Engineer.

2. Each keyed switch shall be clearly and permanently labeled on engraved metal plates, including ON-OFF and UP-DOWN selection.

3. Keys and cylinders shall be Designated Matching Product "Allen Bradley" cylinders keyed to D018 Allen Bradley key with keyways. The UP-DOWN key switch shall be model #800T-J631A and the ON-OFF key switch shall be

Model #800T-H33B. The Engineer will furnish Type Tumbler information upon request.

a. Display panel swinging door lock shall be:

1) Best IC7M1 – 626A A1 core.

2) Best 1A1M1 – KS473-KS800 core key.

3) Best 1E7D4 – C228-RP3-626 cylinder key A1 core.

B. Key Switch Operation

1. Both ON-OFF key switches must be in the ON position in order to start the unit. When either one (or both) are in the OFF position, the unit shall not run, either in automatic or maintenance mode.

2. If both ON-OFF switches are in the ON position, and either UP-DOWN key switch station is actuated for a minimum of two seconds in the desired direction, it operates the unit on automatic mode in that direction. This feature is disabled during maintenance mode.

3. Once the unit is running in the automatic mode per the UP-DOWN direction selection, when either ON-OFF key switch actuated to the OFF position, it stops the unit immediately with the brake, as any other safety device will stop the unit.

4. The change of direction shall only be possible after the escalator is stopped.

5. If the UP-DOWN directional key switch is held in either direction without interruption for 10 seconds, the unit will stop with a stuck key switch fault and a reset is required. This includes if the unit is running up and the down input goes high for 10 seconds (or the opposite), a stuck key switch fault appears and requires a reset.

C. Safety Devices:

1. Provide safety devices required by applicable codes and publications referenced herein on each escalator.

2. Safety devices, depending upon interruption of electric circuit for their operation, shall be interlocked to remove the electric power supply to the motor and shall apply the brakes to bring the escalator to a smooth, safe stop in the original direction of travel.

3. Safety devices shall be mounted in locations accessible for maintenance within escalators, and these devices shall be designed for ease of adjustment or reset. Devices shall be so located that their operation will not be affected by moisture or debris.

4. If escalators are equipped with a braking system dependent upon activation of springs, then the springs shall be of a guidance compression type. The use of weights or self-excitation of the brake release shall not be allowed.

5. Disconnect switches capable of being locked in the “off” position shall be provided at the upper and lower pit of each escalator to prevent the starting of the escalator from any other location.

6. At each escalator, Contractor shall provide the safety devices that shall interrupt electric power within escalator, and automatically apply brakes and bring escalator to a smooth stop in the original direction of travel in accordance with ASME 17.1.

7. Emergency Stop Button:

    a. Emergency stop button shall be provided in accordance with ASME 17.1.

    b. Stop buttons shall be watertight, momentary contact push buttons, stet, shall bear the label of a national recognized testing laboratory, and be constructed in accordance with UL Standards.

8. A switch shall prevent operation of the escalator if any part of the floor plate is not in place. This shall not be a manual reset device.

2.11 BRAKES

A. Each escalator at a minimum shall be provided with the following brakes for stopping and locking of movable drive components:

1. Motor brake shall be located on the motor shaft. Brake shall safely stop escalator upon activation of normal stop control, local or remote emergency stop buttons, activation of any safety device, or upon loss of power.

2. Service brake shall be located on the main drive shaft. Brake shall mechanically lock linkages to truss when repair work is being performed within truss.

B. Operational Sequence

1. Driving-Machine Brake shall be provided in accordance with ASME A17.1.

    a. Brake shall be mechanically or magnetically applied (fail safe) and electrically released. Brake shall be capable of stopping and holding an escalator at the Machinery Rated Load.

    b. The brake shall be designed per prevailing version of ASME A17.1 at time of contract signing. Stops shall be gradual and not abrupt.

    c. Deceleration shall be smooth, gradual, and with no sudden stops.

    d. There shall be no time delay designed into the application of the brake.

    e. Design of brake shall provide ease of access to brake equipment for inspection maintenance, and replacement.

f. The brake operating temperature shall not exceed 195 degrees Fahrenheit above ambient. Temperature and wear monitors shall be provided, and if brake lining becomes insufficient for safe usage, restart of escalator shall be prevented and reported as a brake wear fault. When energized and released, a contact closure indication shall be provided to the controller.

g. The brake coil shall be insulated to Class F.

h. Brake assembly shall be protected from falling water and debris by a removable cover. Cover shall not be higher than six inches above brake assembly.

2. Service Brake

a. Brake shall be manually applied and mechanically engaged to prevent movement of the stepband, while escalator is disconnected from its power supply.

b. An electrical interlock shall be provided that shall prevent escalator drive motors from starting while service brake is engaged.

2.12 STEPS

A. Provide a minimum of three or four flat steps per rise criteria at upper and lower ends within one-sixteenth inch of each other as defined in ASME A17.7 and APTA.

B. The steps shall be one-piece die cast aluminum with no more than 0.3 percent copper content designed to carry a load of 320 pounds per step under eccentric loading conditions with a maximum distortion of 5/32 of an inch with an ultimate strength safety factor of eight (8).

C. The step roller wheels shall be designed for quiet operation and shall be a type that will assure rotation and prevent flat spots. They shall be mounted to prevent tilting and the rocking of the steps in excess of one-sixteenths inch maximum at the step's extremity. They shall be provided with sealed bearings. Step roller wheels shall be tired with synthetic composition materials. Bearings shall have an ABMA median life (L50) 200,000 hours calculated in accordance with ABMA Standard 9 or 11. Step roller outer diameter shall be minimum four inches.

D. The design of the steps and their various attachments shall permit step removal without disturbing the balustrades or dismantling any part of the chains. Lock washers shall be provided on all tap bolts, and lock washers and lock nuts or an approved equal shall be on all through bolts.

E. Refer to ASME AS17.1 for step demarcation requirements.

2.13 STEP DEMARCATION LIGHTS

A. Provide step demarcation lights at the top and bottom of each escalator not to exceed 16 inches from comb plate. Lights shall consist of two, 120vac, five Watt minimum LED light fixtures and waterproof enclosure at each end of the escalator that shall be installed directly below the track system. The fixtures shall be provided with green LED lamps with a color temperature of 5000 Kelvin, which light up the full width of the step separation.

B. Provide redundant strip LED lighting at each landing, activated whenever escalator is in operation.

2.14 STEP CHAINS

A. The step chains shall be of the endless type, one located on each side of the steps. Step chains shall be precision roller-fishplate chains of high grade, heat treated steel, and specifically designed for escalator applications. The pins, bushings, and rollers shall be hardened and ground. Pins shall be interference-fit into the outer links (except for one side of connecting link with detachable side plate) to prevent movement between link plates and pin. Retention of pins to side plates shall be by either riveted (deformed) pin ends, or full circle snap rings except for detachable side plate. Riveted (deformed) pin ends are preferred. The single detachable side plate on the connecting link shall be interference-fit into inner links to prevent movement between link plates and bushing. No split bushings shall be allowed. Master links shall be retained with full-circle snap rings requiring special pliers for removal, per BART Engineering Specifications. BA-ENG/ES 02/EM025.

B. Materials and manufacturing methods employed shall be designed to provide long (seven to 10 years) service life, under heavy traffic exposure to weather, corrosive fluids, and dusty conditions. Actual warranty requirements shall be per General and Special Provisions of the Contract.

C. A shielding device shall be provided to protect the chain track guides, and rollers against water, debris, and dirt.

D. The chains shall be designed for 320 pounds per step load:

1. The step chain and chain pins pressure at engaging points shall be less than 4350 per square inch based on the machine rated load.

2. The breaking factor of safety of a step chain shall be at least six (6) based on the machinery-rated load.

E. Pins shall comply with the following requirements:

1. Surface hardness of the pin OD and bushing ID shall be 60-64 HRC, Knoop 500 gram micro-hardness shall be 732-822 over a case depth of 0.01 inch below the finish ground surface per ASTM E 384.

2. Tensile strength: 1200 Newtons per square millimeter.

3. Diameter: One inch minimum.

4. Pin center to pin center length shall not exceed 133 millimeters.

5. Pin outer surface and bushing inner surface shall be finish-ground after hardening. All parts shall be completely de-burred and ready for installation.

F. Matched lengths of chain pairs shall have their length difference documented, and certificates shall be shipped in the box with each pair.

G. Provide minimum four-inch diameter synthetic composition rollers, to meet BART Engineering Specifications, with sealed ball bearing at each step to support the chain and leading edge of the step.

H. Provide three extra links per each escalator step chain assembly or step chain section to permit the selection of a link by the Engineer for testing. The Engineer may randomly select a link from anywhere along the length of the step chain. Contractor is responsible for testing by independent lab subject to approval by the Engineer specified under Article 3.03, Field Quality Control, herein.

2.15 ROLLERS

A. Roller centers shall be made of cast aluminum alloy or bar stock aluminum alloy 6061-T6. The roller center shall incorporate positive bearing retention to ensure that the bearing is retained without movement in the roller center for the life of the bearing.

B. The bearing shall be full-contact, double sealed ball bearings, SKF, NTN, SNR, or equal.

C. Bearings shall be pre-lubricated by the bearing manufacturer for the life of the bearing.

D. Bearing manufacturer shall be ISO 9000 series certified.

E. The wheels, hubs, and bearings shall an L10 rating of 100,000 hours.

2.16 COMB TEETH SEGMENT

A. The comb teeth shall be epoxy powder coated safety yellow aluminum, with comb teeth so arranged that the cleats of the step treads will pass between them. The comb teeth shall be made in sections so that any damaged or worn section can be replaced without disturbing the balance of comb. The comb teeth shall be formed to correspond to the form of the treads and maintain a uniform side clearance. Comb plate fasteners shall have securing threads of same material as the fasteners to prevent bonding. Inserts are permitted if necessary. All fasteners shall utilize an Allen wrench to remove/replace. Provisions for lateral and vertical adjustment shall be provided so that cleats of steps tread pars between comb teeth with minimum clearance.

2.17 HANDRAILS AND HANDRAIL DRIVE SYSTEMS

A. Traction drive handrail system shall maximize the contact around the upper newel drive wheel and provide a minimum positive drive contact of 48 inches. Handrails shall be firmly engaged by the drive and shall not have any slippage during start-up or running in either direction. No back-bending of the handrail at any point throughout the entire drive path is strongly preferred.

B. Handrails shall receive their motion from main escalator drive through direct gearing, drive shaft and drive chains or drive chains as a minimum, so that handrail and steps operate at the same speed in each direction of travel. Handrail drive chains shall be minimum ANSI No. 80 up to 18 feet rise, minimum ANSI No. 100 for greater than 18 feet rise or ISO equivalent. Driving and guiding wheels shall have a groove to accept the wedge on the underside of the handrail where applicable.

C. Handrail drive system shall be designed to permit installation of replacement handrails without field splicing.

D. Provide convenient way of adjusting handrail tension and drive chain tension.

E. Newels meeting the following requirements shall be provided:

1. Newels shall be designed and constructed so that handrail shall return into newel end at a point inconspicuous and difficult for passengers to reach.

2. Newel sheaves shall be provided at upper and lower newels. Newel wheels shall have minimum two-inch shaft with extra heavy-duty hubs and bearings, four-inch O.D. tapered roller one-and-a-half-inch thick sealed cup and cone bearings.

3. Handrails, handrail drive system, and guides shall be so designed and installed that handrail cannot be thrown off or disengaged while running, and special design attention shall be given to area where handrail passes from drive system to guides. Stationary guides at the newel return shall not be considered acceptable. A method of guiding the handrail and reducing friction by a large diameter newel wheel shall be provided.

4. Newel sheaves shall have sealed bearings that have provision for retention of lubricant to ensure satisfactory lubrication and operation. Additional lubrication shall not be required.

5. Friction drive wheels and idlers shall be designed and positioned so that lubricant cannot reach surface of handrail. Marking and spotting of handrail by drive equipment shall not be permitted.

F. Handrail color shall be black and shall be constructed of laminated, steel, wire mesh, or steel cable reinforced, flexible elastomer material vulcanized into an integral, non-separating, seamless, smooth handrail resistant to environmental conditions. A “V” shaped underside design shall be used, providing a more positive drive. No cotton fabric shall be used. Black color pigment shall be integrated into the polymer; painting shall not be acceptable.

G. The elastomer shall be molded and vulcanized into the carcass assembly. The adhesive bonding of the laminated components shall be scale 4 as defined in ASTM D-2630. The elastomer shall be composed of high quality chlorosulfonated polyethylene, Dupont Hypalon, or equal. The compound is to have an ultimate tensile strength of 1500 pounds per square inch, in accordance with ASTM D412. The interior polymer shall be a thermally stable monosulfide crosslink. All formulations are to contain ultraviolet and ozone inhibitors for resistance to outdoor aging. When tested in accordance with ASTM D1149 there shall be no cracking of the surface visible under 2X magnification. The surface of the cast elastomer shall be smooth and free of irregularities cause from splicing or mold section marks protruding more than one-sixteenth inch (0.0625 inch). The composite shall be able to withstand elongation equal to 300 percent at break per ASTM D412.

H. Hand rail reinforcing fibers shall be encased in adhesive between the first and second layers to act as tension members.

I. The slider fabric or wear ply shall be constructed of synthetic materials which will not swell when moist.

J. The handrail shall be capable of being bent around a 19 inch diameter sheave at 32 degrees Fahrenheit without visible evidence of buckling, cracking, delaminating, or crazing.

K. Handrail guides shall be continuous on exposed portion of handrails, constructed of material which shall not corrode or pit and shall have a polished, permanent smooth finish to minimize frictional wear to any surface of handrail. On the unexposed portion, guiding shall be by adjustable rollers having sealed bearings, and set in a way so as not to cause wear on the handrail. Gaps between guide sections shall be less than or equal to one-eighth inch and shall be level.

2.18 LANDING PLATES

A. Provide aluminum landing plates designed to be supported on truss heads and covering the entire area of the landing within the outline of the truss. Landing plates of adjacent stairs or escalators that jointly cover the same pit area shall match the landing plates of the new escalator.

B. Landing plates shall be extruded from die cast aluminum in a ribbed pattern transverse to the escalator axis. Ribs shall be designed to provide maximum traction, and shall be finished in the same manner as the comb plates. They shall have exposed portions constructed of material and finish to harmonize with steps and comb plates.

C. Landing plates shall be reinforced, as necessary, to be rigid and able to withstand a live load of 250 pounds per square foot, with a maximum deflection (in inches) equal to L/360, where L is equal to the largest span (in inches) between two support members of the landing plates. Landing plates shall experience zero permanent deflection.

D. Landing plates shall be pivoted to swing upward to a vertical position, or plates may be made in removable sections to provide access to the pit. Plates shall be removed either by removable T-handle lifts or other approved methods. Plates shall not exceed 40 pounds each.

E. Means shall be provided to secure the landing plates in the closed position. All locking means such as bolts or screws shall be captive.

2.19 BALUSTRADES

A. Balustrade panels shall be a minimum of 14 gage stainless steel, Type 316. Refer to Section 2.03.A.2 for finish. Backing panels, where used, shall be noncombustible and subject to Engineer's approval. Stiffeners, brackets, attachment angles and other concealed ferrous metal framework shall be galvanized or constructed of equivalent, corrosion-resistant materials.

B. Balustrade panels shall be attached by means that allow easy assembly and disassembly without the removal of trim, safety brushes, or other flashing.

C. Panels shall be constructed, when practical, in equal lengths for interchangeability.

D. Panels shall have edges sealed against moisture.

E. Panels shall be sized so that no more than one person shall be required to remove a panel. Panels shall be designed to be removed without the aid of special handling equipment other than suction cups. Horizontal and transitional panels shall not exceed 35 pounds in weight. Incline panels shall not exceed 45 pounds.

F. Panels shall be securely attached and also permit easy removal for inspection and maintenance.

G. When framework to which panels are fastened is less than one fourth inch thick, steel backup plates with a minimum one fourth of an inch thickness shall be added which have tapped holes or clearance holes where necessary. Panels shall be attached so as to not affect adjacent panels.

2.20 SKIRT PANELS

A. Skirt panels shall be stainless steel, solid construction, minimum 11 gage thickness, and shall conform to ASME A17.1.

B. The height of the skirt panel above the tread nose line shall be at least one and a half inches measured vertically. The height of the skirt panel below the intersection of the two steps along the incline shall be at least one inch measured vertically.

C. Skirt panels shall deflect not more than one sixteenth of an inch under a force of 150 pounds force.

D. Skirt panels shall have rounded smooth joints and seams.

E. Stiffeners, brackets, attachment angles and other concealed ferrous metal framework shall be galvanized or constructed of equivalent, corrosion-resistant materials.

F. Skirt Panel Fastening Requirements: Panels shall be fastened to their respective supports or mating portions with no exposed fasteners from the side adjacent to the steps.

G. When framework to which panels are fastened is less than one fourth inch thick, steel backup plates with a minimum one fourth of an inch thickness shall be added which have tapped holes or clearance holes where necessary.

H. Skirt panels shall be aligned and adjusted so as to achieve the step/skirt performance index as defined in ASME A17.1 Rule 6.1.3.3.9.

I. Provide black color skirt deflector brushes in accordance with ASME A17.1 Rule 6.1.3.3.10 along the skirt panels to keep people’s feet away from the skirt panels.

2.21 DECK COVERS AND MOLDINGS

A. Deck covers and molding shall be a minimum of 14 gage, stainless steel, Type 316. Refer to Section 2.03.A.2 for finish.

B. Surface joints in the deck covers shall be metal-to-metal with gasketed joints below the surface to provide a waterproof seal. Where concealed fastenings cannot be used, exposed fastenings shall be countersunk flush, tamper-proof, and finished to match the adjacent materials.

C. Decking of the escalators shall be designed to support a live load of 175 pounds per square foot, without surface deflection.

D. Paneling, decking, and other enclosures shall be supported on steel framework. Deck covers shall be attached to the truss framework without the use of exposed screws. Decking shall be sloped to prevent ponding of water anywhere.

E. Baggage stops shall be provided on any decking surface exceeding four inches in width per code. Each stop shall be at least 1.875 inches in diameter, two inches high, made of stainless steel and fastened securely using two fasteners to prevent turning and loosening. The distance between stops shall be no less than seven feet. Provide top and bottom terminal baggage stops which shall have a three eighths inch diameter horizontal hole to permit locking of maintenance barricades.

2.22 ENERGY EFFICIENT MOTOR CONTROLLER

A. Provide a motor controller that monitors and varies the current and voltage waveforms to achieve power savings when the escalators are under light load.

2.23 MISCELLANEOUS

A. Contractor shall provide at least one folding step inside the top and bottom escalator pits to assist the mechanics entering and exiting the escalator pits. The steps shall be painted bright yellow and labeled with black lettering reading “STEP”.

B. Duplex receptacles with GFI circuits shall be provided in the upper and lower pits and in the escalator machine room. Receptacles shall be industrial grade 120 Volt, 20 Amp receptacles housed in stainless boxes and covers with watertight snap covers.

C. Pit lights shall be installed in upper and lower pits. Fixtures shall be equipped with polycarbonate clear globe, protective metal grille and 120 Volt, 5000 lumen lamps.

D. Skirt band lighting shall be provided at the skirt band above the skirt brush holder or within the skirt panels with 20 foot candles on the surface of the steps. LED color temperature shall be 4000 Kelvin.

PART 3 – EXECUTION

3.01 PREPARATION

A. Verify dimensions in the field before proceeding with the work. Verify the following to be acceptable for installation of escalators:

1. Wellways size, location and ancillary installations.

2. Truss supports.

3. Electrical conduits and wiring.

B. Correct unsatisfactory conditions prior to proceeding with the work. Where escalator is being installed in an existing wellway, notify the Engineer immediately if unsatisfactory conditions exist, and do not begin installation until non-compliant conditions have been corrected.

3.02 INSTALLATION

A. General: Install in accordance with the requirements of the manufacturer and regulatory agencies and as specified herein. Lubricate all equipment per manufacturer’s instructions. Adjust brakes, controllers, switches, handrail tension and safety devices to achieve required performance.

B. Adjust skirt panels plumb with a maximum running clearance gap of not more than one-eighth inch at any point between steps and skirt panels.

C. Galvanized surfaces that have become damaged from welding, handling, or installation shall be repaired immediately after installation with galvanizing repair material in accordance with ASTM A780.

D. Truss field splices shall be rigid, non-deforming, and shall maintain the truss alignment and structural integrity.

E. Coordinate with the Engineer to install and test connections between the escalator and the train control room, communications room, and station agent booth as indicated.

F. Controllers shall have 6 inches minimum clearance on all four sides (not including front and back).

3.03 FIELD QUALITY CONTROL

A. General

1. Contractor shall notify the Engineer seven Days prior to each scheduled test. Contractor shall perform testing in the presence of the Engineer and appropriate State and other jurisdictional authorities.

2. Contractor shall notify Engineer, a minimum of seven Days in advance of final acceptance tests.

3. Regulatory Agencies Inspection: Upon completion of escalators, the Contractor shall provide instruments, weights and personnel to conduct tests required by regulatory agencies and the Contract Documents. The Contractor shall submit a complete report describing the results of the tests, to the Engineer for approval.

B. Step Chain Testing: Step chain links shall be tested by an independent laboratory approved by the District, paid by Contractor, to demonstrate compliance with the Contract Specifications and the escalator manufacturer's step chain specifications. Links to be tested will be selected by the Engineer. If links fail to comply with the specifications, step chains will be rejected and additional test shall be required on the replacement step chains at no additional cost to the District. Tests shall be witnessed by the District and documented by the Contractor. Test records shall be submitted to the District for approval.

C. Acceptance Testing Requirement

1. Testing shall be performed after installation and before substantial acceptance of the escalator and the escalator is placed in service. Tests shall be witnessed by the District and documented by the Contractor. Test records shall be submitted to the District for approval.

2. Contractor shall perform the following tests on each escalator without load:

   a. Safety devices and switches shall be operated to verify proper shutdown of escalator in both directions.

   b. Safety devices reported by the remote monitoring system shall be tested to verify proper reporting to the local fault indicators and Central Monitoring system.

c. A comb plate impact test shall be performed at each landing to verify both vertical and horizontal force activation.

d. A skirt deflection and test friction shall be performed to verify compliance with ASME A17.1.

e. Contractor shall demonstrate the escalator is operating at the proper speed in both the normal and maintenance modes of operation.

f. Push buttons, starting switches, starters, relays, interlocks, and controls required in connection with work: Inspect and test to prove that complete escalator functions properly under all conditions of operations within limits specified.

g. Conductors for power and control wiring before connected: Test for functionality, continuity, isolation and grounding.

h. Escalator shall produce no noise louder than 65 decibels measured at a distance of 48 inches above the floor or stair level at the entrance combs at both ends with the escalator operating normally, either free-running or under load. Ambient noise level shall not exceed 55 decibels while performing the test.

3. A full load test shall be performed for each escalator prior to Acceptance, to demonstrate braking operation as described herein.

a. Escalator shall be loaded with test weights, as required to meet the machinery rated load. Weights shall be distributed along the escalator as necessary to provide a sufficient number of empty steps to permit the escalator to stop without any test weight hitting the comb plates. Detail of loading to be approved by the Engineer. Load weights shall be supplied by the Contractor.

b. Both static and dynamic tests shall be performed.

c. Braking performance shall be observed and recorded over five consecutive stops for zero percent, 25 percent, 50 percent, 75 percent and 100 percent of the machinery rated load by operating escalators in the down direction, and for zero percent, 25 percent and 50 percent of the machinery rated load by operating the escalator in the up direction.

d. Motor current readings shall be taken and recorded during each condition. Deceleration and stopping distance of the escalator shall be measured and recorded for each test. Deceleration shall be measured using a calibrated accelerometer or other means approved by the Engineer. A report with complete documentation and records for each test shall be submitted to the Engineer for approval within seven Days of the completion of the tests.

D. Correction: Make corrections to defects or discrepancies at no cost to the District. Should discrepancies be such that re-examination and retesting is required, all costs, including those of the District’s representative, shall be paid for by the Contractor.

3.04 REGULATORY AGENCIES INSPECTION:

A. Upon successful completion of escalator testing, the Contractor shall schedule the necessary inspections with the appropriate State Agency for all necessary permits as specified in Section 1.12 Permits.

B. Contractor shall facilitate the regulatory agencies inspection in the presence of the Engineer.

C. The Contractor shall provide instruments, weights, and personnel to conduct any tests required by regulatory agencies.

D. The Contractor shall obtain evidence of permit to operate from the State Agency to the Engineer.

3.05 TRAINING

A. Training Program: The Contractor shall provide a program to train the District's operations, maintenance, and training personnel in details of the escalator system as required to enable the District to operate, service and maintain this system such that this system will perform and continue to perform in accordance with the requirements of this Contract. In regard to work of this Section, these provisions supersede Section 01 79 00, Demonstration and Training.

1. The training program shall include formal and informal instruction, as appropriate, and any models, mockups, documentation, and aids to carry out the program.

2. Materials used in the training program shall be of durable construction and shall become the property of the District.

3. Assumptions:

    a. The Contractor shall assume that the personnel to be trained have only the basic skills pertinent to their craft as outlined in the District's job descriptions for the involved personnel.

    b. The Contractor shall assume that the District personnel to be trained by the training program have no knowledge of features of the equipment or systems to be taught.

4. Training Program Plan: The training program plan shall be submitted within 90 Days of the Notice to Proceed and shall contain, as a minimum, the following data:

    a. A flow diagram indicating the logical progression of training to be conducted;

    b. A description of each course, including the number, description and duration for each lesson in the course.

    c. Resumes showing the qualifications of the proposed instructors;

    d. A list of subcontractors and equipment manufacturers to be used in the training program and a description of their responsibilities;

B. General: The training shall be provided to the District personnel with the operating procedures necessary to operate the systems provided as an integrated entity. The courses shall include the following training:

1. Classroom training shall give course participants an understanding of the overall system operation.

2. Hands-on training shall give course participants actual maintenance experience.

C. Courses: Training shall consist of two courses:

1. Escalator Operations Course:

a. The Escalator Operations Course shall train the District's Station Agents and Station Agents Trainers in the operation of the escalators.

b. The course shall teach how to start, stop, and change the direction of the escalators. The course shall provide a description of the Diagnostic Panel and explain:

1) How to clear simple fault of temporary nature;

2) The conditions under which the station agent may restart the escalator; and,

3) The conditions under which the station agent may not restart the escalator and should request service from maintenance workers.

c. The course duration shall be at least one-half hour.

d. The class size will be up to six participants per session.

e. The course shall be presented four times; two times during day shift and two times during swing shift.

f. Each session shall include specific characteristics of each escalator in the group, if any.

g. Training shall be conducted within 30 Days prior to the anticipated date of escalator in service.

2. Escalator System Maintenance Course:

a. The Escalator System Maintenance Course shall provide the District's maintenance workers and trainers with detail knowledge of and hands-on experience with the system functional capabilities and overall operation in order to properly troubleshoot and maintain escalators. The course shall provide participants with a working knowledge of the system equipment and its operation, interfaces, and use of test equipment for diagnosing troubles.

b. The course shall provide theoretical background and hands-on experience in troubleshooting and repair procedures to permit participants to locate and repair system faults in a timely manner. Course shall include emergency provisions, including emergency access and procedures to be followed at time of failure in operation and other building emergencies. Train personnel in the procedures to be followed in checking the source of operation failure or malfunction. Operation of diagnostic equipment shall be explained.

c. The course shall utilize the complete Operation and Maintenance Manual.

d. The course shall utilize actual hardware and photographs taken during the manufacturing process wherever possible. Actual hardware used for training must pass re-inspection and acceptance testing prior to being placed in service.

e. The course shall consist of a minimum of 16 hours of classroom training and 24 hours of hands-on in the field training. The training shall not exceed eight hours per day.

f. The classroom course shall be presented a total of two times and the field training course shall be presented a total of four times. The Contractor shall present the sessions within 30 Days prior to the end of the Maintenance Period.

g. The class size will be up to 20 participants per classroom session and up to 10 participants in the field sessions.

D. Training Location and Classrooms: Training courses shall be conducted in facilities provided by the District. The facilities will be equipped with tables, chairs, and one cabinet with lock hasp. The Contractor shall provide video players and projectors as required.

E. Instructors: Contractor shall provide qualified instructors. The instructors shall have previous formal classroom instruction training and relevant experience with the provided systems equipment in an operating environment.

1. Classes and instructions shall be presented in person by the instructor.

2. When prerecorded lectures are part of a training course, the instructor shall supplement the recorded material.

3. Instructors shall demonstrate a complete and thorough technical knowledge of the material being covered in the course. These instructors shall be thoroughly familiar with handbooks, guides, tools, test equipment, and other aids used in troubleshooting and repairing the equipment.

F. Training Reports: A grading system shall be established by the Contractor and approved by the Engineer to report the progress of each trainee during a course. Grading shall be kept strictly confidential and furnished only to personnel in the District that are designated by the Engineer. The grading system shall identify any requirements for further training for each participant.

G. Training Manuals and Equipment: The Contractor shall prepare training manuals to supplement the Operation and Maintenance Manuals and submit them to the Engineer for review and approval at least 90 Days prior to the start of classroom instruction. The training manuals shall be prepared specifically for use as training aids. The Operation and Maintenance Manuals shall be the primary text.

1. Each course participant shall receive copies of the Operation and Maintenance Manual, Training Manuals, and other pertinent material prior to the commencement of all courses.

2. The Contractor shall provide the master and two additional copies of Training Manuals and materials as reference documentation.

3. Upon completion of each course, Instructor's Guides, Operation and Maintenance Manuals, Training Manuals, and Training Aids shall become the property of the District. Throughout the Contract and warranty periods, it shall be the responsibility of the Contractor to supply the District with all changes and revisions to the Training Manuals and other documentation.

4. The District reserves the right to copy training materials and aids for use in the District conducted training courses.

5. The Contractor shall provide special tools, equipment, training aids, and any other materials required to train course participants. The number of special tools and other training equipment shall be adequate for the number of participants attending the course.

6. The District will provide the Contractor written comments on the Training, Training Manuals and equipment based upon the first sessions. The Contractor shall incorporate the comments and resubmit the documents 60 Days prior to the end of training.

H. Videotaping:

1. Provide video training tape(s) covering complete troubleshooting of escalator drive/brake/fault finder system.

2. In addition, the Contractor may utilize prerecorded lectures as supplementary training material. These shall not serve as a replacement for a classroom instructor or as the primary training vehicle.

3. The Contractor shall provide such videotapes to the District for retention and playback by the District's Instructors as reference documentation.

4. The District shall have the right to videotape training courses presented by the Contractor. The District shall also have the right to use these videotapes to train personnel in the future.

I. Final Deliverables. The final deliverables consist of:

1. Updated and corrected Instructor Guides, Training Manuals and attachments as specified.

2. Sets of participant's materials, 30 Days prior to commencement of training. Quantity of materials per class size specified herein.

3. Any models, mockups, simulations, or other materials that are not supplied elsewhere in this Contract and that are needed to stage the training program.

3.06 CLEANUP DURING CONSTRUCTION

A. The Contractor shall keep escalator area and the space allocated to the Contractor's work in a neat and orderly condition. The tracks shall be kept clean of debris and metal shavings.

B. The Contractor shall keep any adjacent stairways or escalators clear from debris and provide a safe condition for the public.

3.07 FINAL CLEANING OF FACILITIES

A. Refer to Section 01 74 14, Cleaning. Prior to final inspection by the Engineer, and after each escalator's work is substantially complete, thoroughly clean facilities utilizing professional building cleaners where appropriate.

END OF SECTION 14 31 00

SECTION 20 01 13

RESTORATION OF FACILITY SERVICES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Metal Corrosion Repairs and Painting.

B. Drain and Sewer Cleaning.

C. Ductwork Cleaning.

D. Filter and coil replacement for heating, ventilating, and air conditioning units.

E. Duct replacement.

F. Plumbing fixture replacement.

G. Lighting fixture replacement.

1.02 RELATED SECTIONS

A. Section 01 33 00, Submittal Procedures.

B. Section 01 33 23, Shop Drawings, Product Data, and Samples.

C. Section 01 71 23, Field Engineering.

D. Section 01 74 14, Cleaning.re

E. Section 02 41 19, Selective Structure Demolition.

F. Section 09 91 00, Painting.

G. Section 20 10 13, Common Materials and Methods for Facility Services.

H. Section 20 70 26, Common Materials and Methods for Electrical Systems.

I. Section 22 40 00, Plumbing Fixtures.

J. Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.

K. Section 23 31 00, HVAC Ducts and Casings.

L. Section 23 81 00, Unitary HVAC Equipment.

M. Section 26 50 00, Lighting.

1.03 MEASUREMENT AND PAYMENT

A. General: Separate measurement or payment will not be made for the work required under this Section. All costs in connection with the Work specified herein will be considered to be included or incidental to the Work of this Contract.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM A780 Practice for Repair of Damaged Hot-Dip Galvanized Coatings

B. Steel Structures Painting Council (SSPC):

1. Steel Structures Painting Manual, Volume 2, “Systems and Specifications”

1.05 DESCRIPTION

A. Inspect the existing plumbing system, fire protection system, HVAC systems, and lighting and electrical system for such work that does not meet the requirements of the current California Mechanical Code, California Electrical Code, California Plumbing Code, and California Energy Code, and for providing remediation of such defective plumbing and mechanical work as required to bring the plumbing and mechanical systems up to foregoing referenced Code requirements.

B. Cleaning storm drains, sanitary sewers and sump pumps connected therewith, and HVAC systems’ ductwork within the station or building.

C. The station or building involved in this work will be in continuous operation during the construction period. This will require that the Contractor plan the Work carefully to work around unavoidable obstacles in the prosecution of the Work. It will require further that the Contractor complete some new construction facilities required in the renovation work before removing existing like facilities during transitional work.

D. Provide such additional temporary facilities as may be required to facilitate continuous, unobstructed station or building operations during transitional construction work.

1.06 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. List of Materials: Comply with applicable requirements of Section 20 10 13, Common Materials and Methods for Facility Services – Fire Suppression, Plumbing and HVAC, and Section 20 70 26, Common Materials and Methods for Electrical Systems, for new materials.

C. Shop Drawings: Comply with applicable requirements of Section 20 10 13, Common Materials and Methods for Facility Services – Fire Suppression, Plumbing and

HVAC, and Section 20 70 26, Common Materials and Methods for Electrical Systems, for all plumbing, mechanical, and electrical restoration work.

D. Product Data: Submit individual manufacturer's product data for all manufactured items, materials, equipment, and cleaning agents.

E. Operation and Maintenance Manuals: Comply with applicable requirements of Section 20 10 13, Common Materials and Methods for Facility Services – Fire Suppression, Plumbing and HVAC, and Section 20 70 26, Common Materials and Methods for Electrical Systems.

1.07 QUALITY ASSURANCE

A. Comply with applicable requirements of Section 20 10 13, Common Materials and Methods for Facility Services, and Section 20 70 26, Common Materials and Methods for Electrical Systems.

1.08 STORAGE AND PROTECITON

A. Comply with requirements of Section 20 10 13, Common Materials and Methods for Facility Services, and Section 20 70 26, Common Materials and Methods for Electrical Systems.

1.09 SITE CONDITIONS

A. Comply with requirements of Section 20 10 13, Common Materials and Methods for Facility Services – Fire Suppression, Plumbing and HVAC, and Section 20 70 26, Common Materials and Methods for Electrical Systems. Contractor shall examine the station or building site and compare the drawings with existing condition. The act of submitting shall be deemed that such an examination has been made and that allowanced therefore, have been made in preparing the bid figure. Contractor shall field verify all dimensions and existing conditions prior to commencement of work.

1.10 SCHEDULING OF WORK

A. Trackway drains within the station shall be cleaned during non-revenue hours, 0200 to 0330, Monday through Friday, subject to approval of the work of each shift by the Engineer.

B. Trackway is defined as that portion of the station between station exterior walls and 10 feet inside of each end of the platform.

C. The Contractor shall give thirty Days advanced notice of scheduling for trackway work, and the work is subject to two weeks advance approval by the Engineer. Submit trackway access request on the Monday, 12 calendar Days before the date such access is required, to permit inclusion of this access in the District Track Allocation Schedule.

D. The District may cancel scheduled work on the trackway on or before 3:00 p.m. of the afternoon before the morning the scheduled work will take place without additional cost to the District. Such work shift cancellations or schedule changes may total a maximum of five days per month without additional cost to the District.

E. Station drains, storm drains, and sumps shall be cleaned after all interior renovation and restoration work has been completed, and the Engineer has authorized the work to start. Sumps shall be cleaned after drain lines have been cleaned and flushed.

F. Ductwork shall be cleaned during the renovation of duct systems and before air balancing of the systems.

PART 2 – PRODUCTS

2.01 MATERIALS, EQUIPMENT, AND FACILITIES

A. The Contractor shall provide all materials, tools, equipment, devices, appurtenances, facilities, and services as required for performing the plumbing and mechanical restoration work.

B. Where new materials, equipment, and accessories are required to complete the restoration work as indicated, such new materials, equipment, and accessories shall conform with applicable requirements of Section 20 10 13, Common Materials and Methods for Facility Services, Fire Suppression, Plumbing and HVAC, and Section 20 70 26, Common Materials and Methods for Electrical Systems, and such other Sections as applicable to the Work.

2.02 METAL CORROSION REPAIRS

A. General: Only steel surfaces with superficial rust stains will be considered suitable for corrosion-inhibitive repair work.

B. Black Steel Pipe: Clean rusted steel to bare metal with power disc sanding to remove all evidence or rust, then solvent clean steel surfaces in accordance with SSPC-SP 1 to remove dust and other contaminants. Then, when dry, prime paint with an epoxy-polyamide primer in accordance with SSPC-Paint 22. Finish paint with an industrial grade polyurethane enamel, flat or semi-gloss, black in color.

C. Galvanized Steel Pipe and Ductwork: Clean rusted galvanized steel to bare steel with power disc sanding to remove all evidence of rust, then solvent clean in accordance with SSPC-SP 1 to remove dust and other contaminants. Then cold-galvanize removed and damaged galvanized surfaces with galvanizing repair material meeting requirements of ASTM A780. Apply second coat of galvanized repair material in accordance with the manufacturer’s application instructions, and feather-out so as to become almost invisible.

D. Copper and Brass Pipe and Fittings: Clean thoroughly with solvent that will not damage or weaken soldered joints.

2.03 CLEANING AGENTS

A. Provide commercial grade cleaning agents manufactured specifically for the intended purpose and certified by the manufacturer as biodegradable. Products, solution-mix ratios, application methods, and drain injection volumes shall be as recommended by the cleaning agent manufacturer and approved by the Engineer. Submit manufacturer's product data in accordance with the foregoing specified submittal requirements.

2.04 REPLACEMENT FILTERS AND COILS

A. Refer to Section 23 81 00, Unitary HVAC Equipment, for filter and coil requirements.

PART 3 – EXECUTION

3.01 INSTALLATION GENERAL REQUIREMENTS

A. Installation of renovated and restored work shall conform with applicable requirements for new work as specified in the pertinent Sections.

B. The Work of this Section includes cleanup and cleaning of all restored surfaces as specified in Section 01 74 14, Cleaning.

C. The Work of this Section includes touch-up painting and full painting of surfaces, as indicated. Where touch-up painting is indicated or required, such touch-up painting shall be of the same color and finish texture as existing adjacent surfaces, and overlaps with existing painted surfaces shall be feathered out so as to be invisible in the finished work. Where new painting is required of new completed surfaces, conform with applicable requirements of Section 09 91 00, Painting.

3.02 DRAIN AND SEWER CLEANING

A. Drains, storm drains, and sanitary sewers shall be cleaned within the station limits and beyond to the exterior manholes.

B. The area around each drain, storm drain and sewer cleanout shall be barricaded prior to the commencement of work.

C. Every drain in the station or building shall be cleaned, prior to cleaning the lines, as follows:

1. Drain covers shall be removed and cleaned, both sides.

2. Drain body and trap shall be cleaned using a high-pressure water jet.

3. Drain covers shall be reinstalled using new stainless steel fasteners.

D. Cleanout covers shall be removed and the area around each cleanout plug shall be cleaned and rendered completely free of debris before removing cleanout plug.

E. Each cleanout plug shall be removed, one at a time, and each line cleared first with auger “snake” and then with high-pressure water jet.

F. Once all drains and sewer lines have been cleaned, sumps shall be cleaned as follows:

1. Operate sump pumps manually to draw level down to within 6 inches above top of pump or to within two feet of the bottom of the sump.

2. Remove all sediment from sump using Contractor furnished and operated pump or other Engineer approved methods. The sediment may be either discharged directly into existing discharge line, by means of and Engineer-approved, field installed saddle tapping tee (“hot tap”) with tapping valve installed downstream of the existing pump discharge shut off valves or by use of disposal drums that when filled shall be transported off site and contents disposed of in an Engineer-approved manner. If tapping tees and valves are used, they shall be left in place and a removable cap or plug shall be installed on the valve end.

3. After sediment has been removed from each sump, the walls, floor, and pump in each sump and the sump room floors and sump cover and frame shall be cleaned using high pressure washer and Engineer-approved detergent. Avoid water entering pump controller panel and level-limit switch controls and physical damage to pump and controls. Do not use hot water or steam.

3.03 DUCTWORK CLEANING

A. Ductwork, registers, grilles, and diffusers, as indicated, shall be cleaned.

B. Registers, grilles, and diffusers shall be removed and cleaned using Engineer-approved detergent, rinsed with clean water, and towel dried.

C. With registers, grilles, and diffusers removed, ductwork, including ducts to be modified, shall be vacuum cleaned using powered rotating brushes and vacuum unit specifically designed for ductwork cleaning applications.

D. The volume control dampers installed in the ductwork shall be removed where accessible or moved out of the way to facilitate cleaning. The duct shall be cleaned on either side of multi-blade fire or volume control dampers and the damper blades shall be cleaned through access panels or removed and cleaned where practical.

E. Existing fan blades, coil faces, and fan housings shall be vacuum cleaned. Fan bearings shall be lubricated, and drive belts examined and the condition reported to the Engineer.

F. Volume control dampers shall be returned to their original settings.

G. Filters shall be replaced with filters meeting the requirements of Section 23 81 00, Unitary HVAC Equipment.

H. Cleaned grilles, registers, diffusers, and dampers shall be reinstalled as required for a complete and finished installation.

I. HVAC systems shall be balanced in accordance with Section 23 05 93, Testing, Adjusting, and Balancing for HVAC

J. Fire Damper fusible links shall be replaced with matching links approved by the Engineer.

END OF SECTION 20 01 13

SECTION 20 07 13

PLUMBING AND HVAC INSULATION

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Piping insulation.

B. Duct insulation.

C. Equipment insulation.

D. Insulation finishes.

E. Adhesive coatings and sealing compounds.

F. Protection shields.

G. Insulation inserts.

H. Fasteners.

1.02 RELATED SECTIONS

A. Section 09 91 00, Painting.

B. Section 20 10 13, Common Materials and Method for Facility Services.

1.03 MEASUREMENT AND PAYMENT

A. General: Separate measurement or payment will not be made for the work required under this Section. Costs in connection with the Work specified herein will be considered to be included or incidental to the Work of this Contract.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM B209 Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate

2. ASTM C195 Standard Specification for Mineral Fiber Thermal Insulating Cement

3. ASTM C533 Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation

4. ASTM C534 Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form

5. ASTM C547 Standard Specification for Mineral Fiber Pipe Insulation

6. ASTM C553 Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications

7. ASTM C612 Standard Specification for Mineral Fiber Block and Board Thermal Insulation

8. ASTM C921 Standard Practice for Determining the Property of Jacketing Material for Thermal Insulation

9. ASTM C1136 Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation

10. ASTM D774 Test Method for Bursting Strength of Paper

11. ASTM D828 Test Method for Tensile Properties of Paper and Paperboard Using Constant-Rate-of-Elongation Apparatus

12. ASTM E84 Test Method for Surface Burning Characteristics of Building Materials

13. ASTM E96 Test Methods for Water Vapor Transmission of Materials

B. Federal Specifications (FS):

1. FS L P 535 Plastic Sheet (Sheeting): Plastic Strip: Poly(Vinyl Chloride) and Poly(Vinyl Chloride Vinyl Acetate), Rigid

2. FS SS C 540 Coal Tar (Cutback) Roof Coating, Brushing Consistency

3. FS WW H 171 Hangers and Supports, Pipe

C. Department of Defense, Military Specifications (MIL):

1. MIL A 3316 Adhesives, Fire Resistant, Thermal Insulation

2. MIL C 18480 Coating Compound, Bituminous, Solvent, Coal-Tar Base

3. MIL C 19565 Coating Compounds, Thermal Insulation, Fire- and Water-Resistant, Vapor-Barrier

4. MIL C 20079 Cloth, Glass; Tape, Textile Glass; Thread, Glass and Wire-Reinforced Glass

D. Underwriters Laboratories Inc. (UL):

1. UL 723 Test for Surface Burning Characteristics of Building Materials

E. NAIMA National Insulation Standard

F. NFPA 255 Standard Method of Test Surface Burning Characteristics of Building Material

G. California Code of Regulations and Energy Conservation Standards California Mechanical Code

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Product Data: Submit manufacturer's product data showing and describing the specified products.

C. Certificates of Compliance: Submit certificates of compliance with specified requirements for proposed products.

1.06 QUALITY ASSURANCE

A. Provide satisfactory test results from National Bureau of Standards, or satisfactory certified test report from an accepted testing laboratory, indicating that fire hazard ratings for products proposed for use do not exceed those specified.

B. Products or their shipping cartons shall bear a label indicating that the fire and smoke hazard ratings are as specified.

C. Provide fire resistance values as follows:

1. Components of insulation for piping, ductwork, and equipment, except unicellular insulation, canvas and flexible tubing, including coverings, mastics, and adhesives, shall have fire hazard classification with flame spread and fuel contributed and smoke developed rating of 25/50/50 in accordance with ASTM E84, NPFA 225 and UL 723, as applicable.

2. Provide materials listed in UL Building Materials Directory under heading Hazard Classification (Fire), or tested by accepted testing laboratory in accordance with UL criteria.

3. Test materials that are factory applied and assembled. Test materials that are field applied individually.

4. Do not employ fungicide or corrosive treatment to impart flame resistance. Flame proofing treatments subject to deterioration due to effects of moisture and high humidity are not acceptable.

PART 2 – PRODUCTS

2.01 PIPING INSULATION

A. Provide piping insulation in accordance with the requirements of ASTM C547 and Table 1. Insulate fittings, flanges, and valves except valve stems, handwheels, and operators with pre-molded, either precut or job fabricated, insulation of equivalent thickness and of same composition as insulation installed on adjacent piping. Thickness of insulation shall be in accordance with applicable requirements of the California Energy Code, unless otherwise indicated.

B. Restrict use of unicellular insulation to run outs serving individual terminal units not to exceed 12 feet in length, piping on packaged equipment, and piping exterior to a building.

C. Provide vapor barrier jackets, factory-applied, on pipe insulation except on hot water lines insulation, or unicellular insulation.

Table 1 - Insulation Material for Piping

Service	Materials All Services	Specification	Type	Grade/ Class
Domestic hot water	Mineral	ASTM C547	DIII	12
Electric water cooler drain	Mineral fiber	ASTM C547	DIII	12
Air conditioner interior condensate drain piping	Mineral fiber	ASTM C547	DIII	12
Refrigerant suction	Uni-cellular tubular line	ASTM C534		
Diesel engine exhaust	Calcium silicate	ASTM C533		
Chilled water pipes	Flexible Elastomeric Closed Cell Foam	ASTM C534	1	3

2.02 DUCT INSULATION

A. Provide fibrous glass air conditioning and heating duct insulation conforming to ASTM C612, Class 1, of ten pound per cubic foot density for rigid insulation, and conforming to ASTM C553, Type I, Class B-4, of 1.5 pounds per cubic foot density for flexible connections. Insulation for air conditioning ducts shall be provided with 0.002 inch foil scrim facing.

B. Duct insulation shall meet requirements of California Mechanical Code, including insulation thickness. No insulation or sound proofing is allowed to be installed inside the supply and return air ducts. Apply insulation in accordance with the requirements shown in Table 2.

Table 2 - Insulation Material for Ductwork

Ductwork	Material	Type	Specification	Class
Outside air intake duct	Glass fiber	Rigid	ASTM C612	1
Outside air-conditioned air plenums	Glass fiber	Rigid	ASTM C612	1
Conditioned air supply ducts exposed to outside air	Glass fiber	Rigid	ASTM C612	1
Conditioned air supply ducts from fans to vertical ducts in shafts	Glass fiber	Rigid	ASTM C612	1
Conditioned air supply ducts, vertical shafts	Glass fiber	Rigid	ASTM C612	1
Conditioned air supply ducts concealed	Glass fiber	Flexible	ASTM C553	Commer
Conditioned air supply ducts, exposed	Glass fiber	Rigid	ASTM C612	1
Conditioned air in mechanical equipment room	Glass fiber	Rigid	ASTM C612	1
Conditioned air return ducts in spaces not air conditioned or heated	Glass fiber	Rigid	ASTM C612	1

2.03 EQUIPMENT INSULATION

A. Provide rigid fiberglass insulation, two inches thick, conforming to ASTM C612, Class 1, of 10 pounds per cubic foot density.

B. The following equipment shall be insulated:

1. Drip pan under chilled equipment.

2. Roof drain bodies.

2.04 INSULATION FINISHES

A. Provide vapor barrier jackets for piping, ducts, and equipment insulation conforming to ASTM C1136, Type I or II for piping and equipment, and Type II for ducts.

B. Provide pre-sized glass cloth jacket with or without integral vapor barrier. Jacket with integral vapor barrier may be used instead of the vapor barrier specified herein, and with a perm rating as specified in ASTM C1136, Type I or II for the vapor barrier jacket for the applicable service. Provide glass cloth jackets having a bursting strength of not less than 200 psi in accordance with ASTM D774. Jacket material shall not support fungus growth. Provide factory-applied jackets on the insulation.

C. Provide all-purpose jacket having a perm rating of not more than 0.02 in accordance with ASTM E96, and a tensile strength of not less than 35 pounds per inch of width in accordance with ASTM D828. Provide factory applied all-purpose jacket material on pipe, equipment, and concealed duct insulation. Provide glass-scrim-reinforced white vinyl finish.

D. Provide aluminum jacket, 0.016 inch thick in accordance with ASTM B209.

2.05 ADHESIVE COATINGS AND SEALING COMPOUNDS

A. Requirements: Provide adhesive coatings and sealing compounds that are compatible with materials to that they are applied, and that will not corrode, soften, or otherwise attack such material in either wet or dry state.

B. Adhesives: Conform to the following requirements:

1. Lap Adhesive for Vapor Barrier Jackets: Conform to MIL-A-3316, Class 2.

2. Lagging Adhesive: Conform to MIL-A-3316, Class 1.

3. Insulation Cement: Conform to ASTM C195.

4. Bonding Adhesive: Adhesive for securing insulation to metal surfaces shall be as recommended by the insulation manufacturer.

C. Coating Compounds:

1. Provide coating compound used as a vapor barrier treatment conforming to MIL-C-19565, either Type I or II. Provide white vapor barrier coating where exposed to view.

2. Provide coating compound used as metal protection in accordance with FS◦SS-C-540, and apply a coal tar base coating conforming to MIL-C-18480.

3. Provide weatherproofing coating compound for protective finish outdoors conforming to MIL-C-19565, Type I.

4. Provide glass tape conforming to MIL-C-20079, Type II, Class I.

5. Provide coating compound used as a vapor barrier for fittings on piping systems above 35 degrees Fahrenheit of polyvinyl chloride conforming to FS L P-535, Composition A, Type II.

2.06 PROTECTION SHIELDS

1. Provide half round protection shields conforming to FS WW-H-171, Type 41.

2.07 INSULATION INSERTS

1. Provide insulation inserts at pipe hanger supports for pipe two inches and larger of either calcium silicate, cellular glass, pre-stressed molded glass fiber of minimum 13-pound density, or other accepted material of the same thickness as adjacent insulation and not less than 13-pound density.

2.08 FASTENERS

A. Provide fasteners of corrosion-resistant material. Provide staples of minimum three fourths inch width; thickness not less than 0.005 inch for zinc-coated steel and not less than 0.007 inch for aluminum. Provide speed washers and anchor pins as recommended by the manufacturer for type and thickness of insulation specified. Provide bands for metal jackets three eighths inch wide and 0.015 inch thick of zinc-coated steel or 0.020 inch thick of aluminum.

PART 3 – EXECUTION

3.01 SITE CONDITIONS

A. Test, clean, and inspect surfaces and equipment that insulation will be applied or installed before the Work of this Section begins. Provide surfaces acceptable for the application and installation of insulation products.

3.02 INSTALLATION REQUIREMENTS

A. Piping Insulation: Insulate piping systems as listed in Table 1 herein. Insulate fittings, flanges, and valves unless otherwise indicated.

B. Duct Insulation: Insulate ducts and plenums of heating, ventilating, and air conditioning systems as listed in Table 2 herein. Do not insulate the following ductwork:

1. Air conditioning return ducts in air-conditioned spaces.

2. Heating return ducts in heated spaces.

3. Duct systems at fire dampers.

4. Ventilation exhaust ducts, except hot exhaust ducts in air conditioned space.

C. HVAC Spaces Defined: Air conditioned and heated spaces are defined as those spaces directly supplied with heated or cooled air, or provided with a heating or cooling device such as a fan coil unit.

D. Diesel-Generator Exhaust Pipe Insulation: Diesel engine generator exhaust piping inside building shall be insulated with calcium silicate, as indicated and specified. The stainless steel expansion joint shall be insulated with 100 percent asbestos-free mineral fiber blanket insulation covered with a glass cloth jacket and held in place with stainless steel wire and covered with stainless steel screening. The insulation and screen cover shall not interfere with the movement of the expansion joint.

E. Insulation Finishes for Piping:

1. Provide factory-applied vapor barrier jackets on pipe insulation if concealed in crawl spaces, pipe chases, tunnels, and trenches. Vapor barrier jackets are not required for unicellular insulation.

2. Provide a factory-applied, all-purpose jacket for pipe insulation in exposed locations, except that which is exposed to the weather and unicellular insulation, either with or without integral vapor barrier.

3. Apply two coats of vinyl lacquer to unicellular insulation exposed to the weather.

4. Finish insulated fittings, flanges, and valves as specified in Article 3.02 herein. Finish fittings, flanges, and valves with job fabricated metal covers. Finish elbows and curved piping with factory-fabricated metal covers. Provide covers of the same thickness and material as jackets on adjacent piping. Secure metal covers in place with metal bands, and seal with a waterproof coating.

5. Cover outdoor piping and insulation with aluminum jacket. The jacket shall be held in place by a continuous friction type joint, providing a positive weather seal over the entire length of jacket. The circumferential joints shall be secured with preformed aluminum jackets, two-piece elbows, and flange covers, secured with steel bands.

F. Insulation Finishes for Ducts and Equipment:

1. Provide vapor barrier jacket for insulated equipment. Provide factory-applied vapor barrier jacket for insulated air conditioning ducts.

2. Duct and equipment insulation concealed from view within the building requires no additional finish. Where exposed to the public in buildings, no additional finish is required on plenums, casing, fans, ducts, and equipment insulation where pre-sized glass cloth or all-purpose jacket is the outer surface. Otherwise apply either pre-sized glass cloth or tape embedded in a wet coat of lagging adhesive.

3. Finish plenums, casings, fans, ducts, and equipment insulation exposed to the weather shall be covered with vinyl/PVC jacket.

3.03 INSTALLATION

A. Install insulation material having smooth and even surfaces, jackets drawn tight, and smoothly cemented down on longitudinal and end laps. Do not apply insulation materials until all surfaces to be covered are tested for leaks, cleaned and dried, and foreign materials such as rust, scale, and dirt have been removed. Provide clean insulation when installed and during the application of finish. Neatly finish insulation at pipe and duct hangers.

B. Provide continuous insulation through hangers, sleeves, and wall and ceiling openings, except at fire dampers in duct systems. Insulate piping and ductwork individually.

C. Where plumbing pipes are located in chases and space does not permit installation of sectional insulation, when approved by the Engineer, pipes may have insulation omitted, provided chases are packed full of mineral fiber or rock wool.

D. Provide a complete moisture and vapor seal wherever insulation terminates against metal hangers, anchors, and other projections through insulation on cold surfaces for that a vapor seal is specified.

E. Fill joints, breaks, punctures, and voids with vapor barrier compound, and cover with vapor seal material identical to the surrounding insulation. Seal off ends of pipe insulation with vapor barrier coating at valves, flanges, fittings, and on long runs of pipe at intervals not to exceed 15 feet.

F. Do not insulate chrome-plated pipes and pipes used solely for fire protection. Omit insulation from vibration isolating connections, but neatly terminate and bevel adjacent insulation. Do not insulate access plates in ducts or plenums for air heating systems.

G. Install acoustical and internal duct liner as recommended by the material manufacturer and as specified in Article 3.04.

3.04 PIPE INSULATION

A. Provide sectional pipe insulation (except unicellular insulation) with sections of insulation placed around the pipe and tightly butted into place. Draw jacket laps tight and smooth, and secure with fire-resistant adhesive and non-corrosive outward-clinching staples spaced not over four inches on centers and one inch from edge of lap.

B. Cover circumferential joints with butt strips not less than three inches wide, of material identical to the jacket material. Provide adhesive used to secure the butt strip that is the same as that used to secure the jacket laps. Apply staples to both edges of the butt strips. Seal staples and seams with a brush coat of fire-resistant vapor barrier coating applied at longitudinal and circumferential laps. Staples may be omitted when factory-applied, self-sealing system is used unless fishmouths develop.

C. Coat ends of sections of insulation that butt against flanges, unions, valves, fittings, and joints at intervals of not more than 12 feet on continuous runs of pipe with a vapor barrier coating. Patch breaks and punctures in the jacket material by wrapping a strip of jacket material around the pipe and cementing, stapling, and coating as specified for butt strips. Extend patch not less than one and a half inches past the break in both directions.

D. At penetrations, such as at thermometers, fill the voids in the insulation with vapor barrier coating, and seal the penetration with a brush coat of the same coating.

E. Do not use staples to secure jacket laps on pipes carrying fluid at temperatures below 45 degrees Fahrenheit.

F. Slip unicellular tubular insulation over the pipe or split and apply around the pipe. Seal butt joints and end of tubing with pressure-sensitive vinyl plastic tape or vapor barrier adhesive. Seal longitudinal joints with vapor barrier adhesive, and secure on nine inch centers with pressure-sensitive vinyl plastic tape. Vapor barrier jackets are not required for unicellular insulation.

G. Provide continuous insulation through pipe hangers and pipe sleeves. At hangers where the pipe is supported, provide an insulated protection shield. Provide pipes two inches and larger with insulation inserts at points of hanger supports. Provide inserts having sufficient compressive strength to adequately support the pipe without compressing the inserts to a thickness less than the adjacent insulation. Provide inserts that are 180 degrees and not less than the length of the protection shield. Provide vapor barrier facing of the insert of the same material as the facing on the adjacent insulation.

H. Provide an aluminum jacket over the insulation on pipe passing through sleeves where calking is required. When penetrating interior walls, extend the aluminum jacket two inches out on either side of the wall, and secure on each end with a band. Extend the metal jacket when penetrating floors, from a point below the backup material to a point 10 inches above the floor, with the band at the floor and one not more than one inch from end of aluminum jacket.

I. When segments of insulation are installed, cover flanges, unions, valves, and fittings as specified herein. Provide elbows with not less than three segments. For other fittings and valves, cut to required curvature, or place and join nesting size sectional insulation segments with adhesive. After the segments are in place, apply a vapor barrier coating.

J. Where unions are indicated not to be insulated, terminate the covering neatly at the end of unions with insulating cement troweled on a bevel. Provide a coat of vapor barrier coating on beveled ends. Insulate anchors the same way as piping for a distance not less than six inches from the surface of the pipe insulation. Provide vapor seal insulation for anchors as specified for fittings.

3.05 DUCT, PLENUM, AND CASING INSULATION

A. Rigid duct insulation shall be secured to ducts by impaling over either pins or anchors located not more than three inches from edges of boards and spaced not more than 12 inches on centers. Insulation shall be secured with washers and clips. Pins or anchors shall be connected to duct surfaces with waterproof adhesive especially designed for attachment to metal surfaces. Insulation shall be applied with joints tightly butted.

B. Insulation shall be installed without sag on underside of ductwork. Adhesive or mechanical fasteners shall be used where necessary to prevent sagging.

C. Vapor barrier penetrations shall be sealed by mechanical fasteners with vapor barrier adhesive.

D. Insulation shall be stopped and pointed around access doors and damper operators to allow operation without disturbing wrapping.

E. Insulation and vapor barrier shall be continuous through wall and floor penetrations.

F. Thickness of insulation for ductwork shall be as indicated or specified.

G. Omit insulation on ducts internally lined with acoustical duct liner.

3.06 EQUIPMENT

A. Insulation shall be applied as close as possible to equipment by grooving, scoring, and beveling insulation, if necessary. Insulation shall be secured to equipment with studs, pins, clips, adhesive, wires, or bands.

B. Joints, cracks, seams, and depressions shall be filled with bedding compound to form smooth surface. On cold equipment, vapor barrier cement shall be used.

C. Insulation shall be covered with metal mesh and finished with heavy coat of insulating cement.

D. Insulation shall not be applied over nameplate or ASME stamps. Insulation shall be beveled and sealed around such items.

E. When equipment with insulation requires periodical opening for maintenance, repair, or cleaning, insulation shall be installed in such a manner that it can be easily removed and replaced without damage.

3.07 INSULATION FINISH APPLICATION

A. Factory-apply vapor barrier jackets for piping and facing for ductwork insulation. At Joints, cover the vapor barrier jacket for rigid insulation with either four-inch-wide, pressure-sensitive vapor seal tape or strips of material identical to jackets, or have two-inch-wide laps drawn tight and secured with vapor seal adhesive.

B. Secure the tape or laps with flared staples, spaced 4 inches on centers and 1 inch from edges of tape or laps.

C. Brush coat joints and openings where the facing is pierced or punctured by pins or other means, with two-inch-wide strips of vapor barrier coating compound and vapor seal material to provide a vapor-tight covering.

3.08 PROTECTION AND REPLACEMENT

A. Replace damaged insulation that cannot be repaired to the satisfaction of the Engineer, including units with vapor barrier damage and moisture-saturated units.

B. Provide protection of the finished work during the remainder of the construction period, to avoid damage and deterioration of the insulation and finish coatings and sealants.

3.09 PAINTING

A. Comply with applicable requirements of Section 09 91 00, Painting.

END OF SECTION 20 07 13

SECTION 20 10 13

COMMON MATERIALS AND METHODS FOR FACILITY SERVICES – FIRE SUPPRESSION, PLUMBING AND HVAC

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Standard pipe and fittings.

B. Gas piping.

C. Diesel exhaust pipe.

D. Hydraulic piping for elevators.

E. Hydronic piping and specialties.

F. Branch outlets.

G. Pipe joint materials.

H. Gaskets.

I. Insulating connections.

J. Expansion joints.

K. Y-type strainers.

L. Gages and test plugs.

M. Thermometers.

N. Access doors and panels.

O. Pipe sleeves.

P. Casings.

Q. Valves.

1.02 RELATED SECTIONS

A. Site work and site facilities for water distribution system, sanitary sewerage system, and site drainage system are specified in applicable sections of Division 33, Utilities.

B. Section 08 31 00, Access Doors and Panels.

C. Section 09 91 00, Painting.

D. Section 20 20 13, Pipe Sleeves, Supports, and Anchors for Facility Services.

E. Section 20 30 13, Vibration Isolations and Seismic Control for Facility Services.

F. Section 20 40 13, Identification for Facility Services.

G. Section 21 12 10, Fire Suppression Standpipe.

H. Section 21 13 13, Wet-Pipe Sprinkler System.

I. Section 22 11 01, Water Distribution.

J. Section 22 13 01, Sanitary Sewerage.

K. Section 22 14 01, Storm Drainage.

L. Section 22 15 00, General Service Compressed-Air Systems.

M. Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.

N. Section 23 09 00, Instrumentation and Control for HVAC.

O. Section 23 23 00, Refrigerant Piping.

1.03 MEASUREMENT AND PAYMENT

A. Separate measurement or payment will not be made for the Work required under this section. Costs in connection with the Work specified herein will be considered to be included or incidental to the Work of this contract.

1.04 REFERENCES

A. American National Standards Institute (ANSI):

1. ANSI/ASME B1.20.1 Pipe Threads, General Purpose (Inch)
2. ANSI/ASME B16.1 Cast Iron Pipe Flanges and Flanged Fittings
3. ANSI/ASME B16.3 Malleable Iron Threaded Fittings
4. ANSI/ASME B16.5 Pipe Flanges and Flanged Fittings
5. ANSI/ASME B16.9 Factory Made Wrought Steel Buttwelding Fittings
6. ANSI/ASME B16.11 Forged Fittings, Socket Welding and Threaded
7. ANSI/ASME B16.12 Cast Iron Threaded Drainage Fittings
8. ANSI/ASME B16.18 Cast Copper Alloy Solder Joint Pressure Fittings

9. ANSI/ASME B16.22 Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
10. ANSI/ASME B36.10 Welded and Seamless Wrought Steel Pipe
11. ANSI/ASME B31.9 Building Service Piping Code
12. NSF/ANSI 61 Drinking Water System Components – Health Effects

B. American Society of Mechanical Engineers (ASME):

1. ASME Boiler and Pressure Vessel Code, Section VIII and Section IX

C. American Society for Testing and Materials (ASTM):

1. ASTM A47 Specification for Ferritic Malleable Iron Castings
2. ASTM A53 Specification for Pipe, Steel, Black and Hot Dipped Zinc Coated, Welded and Seamless
3. ASTM A74 Specification for Cast Iron Soil Pipe and Fittings
4. ASTM A105/ A105M Specification for Carbon Steel Forgings for Piping Applications
5. ASTM A135 Specification for Electric-Resistance-Welded Steel Pipe
6. ASTM A139 Specification for Electric-Fusion (Arc) Welded Steel Pipe (NPS 4 and Over)
7. ASTM A153/ A153M Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
8. ASTM A181/ A181M Specification for Carbon Steel Forgings for - General–Purpose Piping
9. ASTM A183 Specification for Carbon Steel Track Bolts and Nuts
10. ASTM A194/ A194M Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure and High Temperature Service
11. ASTM A197 Specification for Cupola Malleable Iron
12. ASTM A234/ A234M Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures
13. ASTM A395 Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures
14. ASTM A536 Specification for Ductile Iron Castings

15.	ASTM A582/ A582M	Specification for Free Machining Stainless Steel Bars
16.	ASTM A795	Specification for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use
17.	ASTM B32	Specification for Solder Metal
18.	ASTM B62	Specification for Composition Bronze or Ounce Metal Castings
19.	ASTM B88	Specification for Seamless Copper Water Tube
20.	ASTM B124	Specification for Copper and Copper Alloy Forging Rod, Bar, and Shapes
21.	ASTM B306	Specification for Copper Drainage Tube (DWV)
22.	ASTM C14	Concrete Sewer, Storm Drain and Culvert Pipe
23.	ASTM C564	Rubber Gasket for Cast Iron Soil Pipe and Fittings
24.	ASTM D256	Test Methods for Determining the Pendulum Impact Resistance of Notched Specimens of Plastics
25.	ASTM D570	Test Method for Water Absorption of Plastics
26.	ASTM D638	Test Method for Tensile Properties of Plastics
27.	ASTM D695	Test Method for Compressive Properties of Rigid Plastics
28.	ASTM D1784	Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds
29.	ASTM D1785	Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
30.	ASTM D2122	Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings
31.	ASTM D2235	Solvent Cement for Acrylonitrile Plastic Pipe and Fitting
32.	ASTM D2466	Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
33.	ASTM D2467	Specification for Socket-Type Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
34.	ASTM D2564	Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems

35. ASTM D2665 Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste and Vent Pipe and Fittings
36. ASTM D2729 Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings
37. ASTM D3139 Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals
38. ASTM F477 Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
39. ASTM F656 Standard Specification for Primers for Use in Solvent Cement Joints of Poly(Vinyl Chloride) (PVC) Plastic Pipe and Fittings

D. American Welding Society (AWS):

1. AWS A5.1 Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding
2. AWS A5.2 Specification for Carbon and Low Alloy Steel Rods for Oxyfuel Gas Welding
3. AWS A5.8 Specification for Filler Metals for Brazing and Braze Welding
4. AWS A5.29 Specification for Low Alloy Steel Electrodes for Flux Cored Arc Welding
5. AWS B2.1 Standard for Welding Procedure and Performance Qualification

E. American Water Works Association (AWWA):

1. AWWA C104 Cement-Mortar Lining for Ductile-Iron Pipe and Fitting for Water
2. AWWA C105 Polyethylene Encasement for Ductile Iron Pipe Systems
3. AWWA C110 Ductile Iron and Gray Iron Fittings, 3 in. Through 48 in. (75 mm Through 1200 mm), for Water and Other Liquids
4. AWWA C606 Grooved and Shouldered Type Joints
5. AWWA C900 Polyvinyl Chloride (PVC) Pressure Pipe, 4 in. Through 12 in., for Water Distribution

F. Cast Iron Soil Pipe Institute (CISPI):

1.	CISPI 301	Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drains, Waste and Vent Pipe Applications
2.	CISPI 310	Specification for Coupling for Use in Connection with Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drains, Waste and Vent Pipe Applications

G. Federal Specifications (FS):

1.	FS GG G 76	Gages, Pressure and Vacuum, Dial Indicating (for Air Stream, Oil, Water, Ammonia, Chlorofluorohydrocarbon Gases and Compressed Gases)
2.	FS WW-P-521	Pipe Fittings, Flange Fittings, and Flanges: Steel and Malleable Iron (Threaded and Butt Welding), Class 150
3.	FS WW-U-501	Pipe Fitting, Cast Iron, Screwed, 125 and 250 Pound
4.	FS WW-U-531	Unions, Pipe, Steel or Malleable Iron, Threaded Connection, 150 pound, 250 pound and 300 pound WSP
5.	FS WW V 1967	Valve, Butterfly (Threaded Ends and Solder Ends), Brass or Bronze

H. Department of Defense, Military Specifications (MIL):

1.	MIL-G-13210	Gaskets, Rubber
2.	MIL-S-16293	Strainers, Sediment, Pipe Line, Water, Air, Gas, Oil
3.	MIL-V-13612	Valves, Relief, Pressure and temperature

I. Manufacturers Standardization Society (MSS):

1.	MSS SP-70	Cast Iron Gate Valves, Flanged and Threaded Ends
2.	MSS SP-80	Bronze Gate, Globe, Angle and Check Valves

J. National Association of Corrosion Engineers (NACE):

1.	NACE RP0274	High-Voltage Electrical Inspection of Pipeline Coatings Prior to Installation

K. Underwriters Laboratories (UL)

1.05 DESCRIPTION

A. The Contract Drawings show piping, ductwork, and facilities diagrammatically and do not show offsets, fittings, and accessories that may be required because of obstructing structural features and architectural finishes, interfering pipelines, ducts, and electrical conduits and devices. The Contractor shall be responsible for investigating all such conditions for determining the implementation of routing pipelines and ductwork around such obstructions and interferences. The Contractor shall provide all such additional fittings, appurtenances, and accessories as required for routing pipelines and ductwork around obstructions and interferences and for providing complete and operable plumbing, mechanical, and fire protection installations.

1.06 REGULATORY REQUIREMENTS

A. In addition to the foregoing referenced standards, the regulatory requirements that govern the work of these Specifications include the following codes and regulations, at a minimum:

1. California Code of Regulations:

    a. Title 8, Subchapter 4, Construction Safety Orders

    b. Title 19, Public Safety, State Fire Marshal

    c. Title 24, Part 2, California Building Code

    d. Title 24, Part 4, California Mechanical Code

    e. Title 24, Part 5, California Plumbing Code

    f. Title 24, Part 6, California Energy Code

    g. Title 24, Part 9, California Fire Code

2. General Orders and Regulations of the State of California, Public Utilities Commission.

1.07 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. List of Materials: Within 35 Days after effective date of Notice to Proceed, submit a complete list of materials and equipment proposed for use together with applicable standards. Submit name of manufacturer, brand name, and catalog number for each item. Submit the list complete at one time, with items arranged and identified in numerical sequence by Specification Section and Article number.

C. Compliance with Applicable Codes and Standards:

1. Where equipment or materials are specified to conform to the standards of organizations such as ANSI, ASHRAE, ASME, and ASTM, submit evidence of such conformance for review and record purposes.

2. The label or listing of the specified agency will be acceptable evidence.

3. Instead of the label or listing, the Contractor may submit a written certificate from an approved, nationally recognized testing organization, adequately equipped and competent to perform such services, stating that the items have been tested and that the units conform to the specified standard.

4. Where equipment or work is specified to conform to the ASME Boiler and Pressure Vessel Code, Section VIII, submit evidence that the equipment, fabrication, and installation of the work conform to the code as required.

5. Submit evidence of compliance with seismic safety requirements in accordance with Title 24 of the California Code of Regulations.

6. Submit evidence that welding methods and procedures comply with all requirements of AWS D10-9, Level AR-3, for joining of piping.

7. Submit evidence of compliance with energy conservation standards of the California Code of Regulations, Title 24, Part 2, California Building Code, and Title 24, Part 6, California Energy Code.

D. Factory Test and Inspection Certification:

1. Except as otherwise specified herein, where factory tests and inspections for materials and equipment specified in referenced documents are waived, provide certified copies of reports for tests performed on previously manufactured identical materials or equipment within the previous 12 months.

2. Accompany test reports by signed statements from the manufacturer certifying that the previously tested material or equipment is physically, mechanically, and electrically identical to that proposed for this work. Include wiring and control diagrams.

3. PVC Fusion Equipment: The Supplier qualifications and equipment, technician certifications, fusion procedure, and joint log data shall be submitted for approval.

E. Shop Drawings: Provide complete details for installation of the following listed items of equipment, assemblies, and appurtenances, including equipment to be furnished by the District:

1. Equipment installation details complete with vibration isolators and seismic bracing.

2. Foundations for equipment anchorage and mounting.

3. Information and templates for installing bolts and studs in foundations.

4. Anchorage and mounting methods, including isolation pads, showing adjustment and alignment.

5. Pipe anchors, supports, and guides.

6. Details of installation of temporary materials and equipment to be used in the work.

7. Layout and complete details for piping and ductwork. Where Contract Drawings are diagrammatic, provide complete details for routing piping and ductwork at obstructions and interferences.

8. Plan for performing the work, including the sequence of operations. Verify by field measurements and show the exact locations of existing utilities.

9. Factory certified performance curves showing capacity and horsepower requirements.

10. Wiring and control diagrams and logic diagrams when solid-state controllers are provided.

F. Installer's Qualification: Certification of qualification of workers installing mechanical equipment, as required by Article 1.08.B herein.

G. Operation and Maintenance Manuals: Submit operation and maintenance instructions and data for equipment provided in accordance with the requirements of Section 01 78 23, Operation and Maintenance Data. Include recommended maintenance materials and spare parts list for installed equipment.

H. Hydronic System Test Reports: Submit written report.

1.08 QUALITY ASSURANCE

A. Installation Standards: Perform installation and testing of plumbing, mechanical, and fire protection work in accordance with the installation instructions and recommendations of the equipment and materials suppliers. Welding material and procedures shall conform to ASME code. Comply with applicable codes and standards listed herein under Reference Standards and Regulatory Requirements.

B. Installer's Qualifications: Installers shall be qualified in accordance with the following requirements:

1. Welders: Section IX of ASME Boiler and Pressure Vessel Code.

2. Plumbers and Pipe Fitters: Under the direct responsible supervision of a plumber licensed by the State of California and subject to inspection by the Engineer.

3. Fusible PVC Technicians: Fusible PVC Fusion butting shall be performed by a technician certified by a District approved butt fusion machine manufacturer. The fusion procedure shall be sourced from a supplier with PVC specific procedure and include clamping, facing, heating, and fusing.

C. Inspection, Certification, and Testing of Coatings:

1. Provide a manufacturer's certificate of compliance for coating materials. Include in the certificate: material identification, quantity, batch number, date of manufacture, and other laboratory data covering requirements of specifications under which the material is furnished.

2. Surface preparation, cleanliness, application, and adhesion shall conform to the coating manufacturers' specifications and will be subject to inspection by the Engineer.

3. Inspection of the pipe coating shall be conducted by a NACE qualified coatings inspector or personnel with equivalent training and experience. Conduct a visual inspection to locate holidays, disbandment, and improper application. Before installation, conduct a high voltage electrical inspection of the coating in accordance with NACE RP0274.

D. PVC Fusion Equipment: Each butt fusion joint shall be data logged for temperature and time. The Supplier qualifications and equipment, technician certifications, fusion procedure, and joint log data shall be submitted for approval.

1.09 INTERFACE AND COORDINATION

A. Interface, coordinate, and comply with the work of this Section as required to provide complete and operable plumbing, mechanical, and fire protection systems.

B. Interface and coordinate with the Sections under Division 26, Electrical, that require electrical equipment and services as part of the mechanical installation.

C. Interface and coordinate the plumbing, mechanical, and fire protection work with the affected utility companies, utility districts, and District representatives as applicable.

D. Coordinate all openings for mechanical equipment in floors, walls, ceilings, and roofs, based on actual dimensions of purchased equipment.

1.10 STORAGE AND PROTECTION

A. Storage: Store all materials and equipment in dry, ventilated, and weather tight enclosures.

B. Protecting Machined Surfaces: Apply a rust preventive on machined surfaces such as flanges and shafts. Use material of a type that is easily removable with solvent during equipment installation.

C. Protecting Openings: Close pipe connections, ends, and other openings with easily removable plugs, stoppers, or flange covers.

1.11 SITE CONDITIONS

A. Visit the site of the Work and thoroughly check details of work and working conditions, verify dimensions in the field, and advise the Engineer of discrepancies before ordering material and equipment or performing work. The Contractor shall be responsible for the coordination and proper relationship of the work to the structure and to the work of other trades.

PART 2 – PRODUCTS

2.01 MATERIAL OR PRODUCTS NOT LISTED IN THIS SECTION ARE NOT ACCEPTABLE. USE ONLY MATERIALS OR PRODUCTS LISTED IN THIS SECTION.

2.02 CLASSES OF STANDARD PIPE AND FITTINGS

A. Class Requirements: Service applications for the following classes of pipe and fittings are specified in other sections of these Specifications, or are indicated on the Contract Drawings. Where more than one class is indicated in the same run, either class may be used, but do not intermingle the classes.

1. Buried: To conceal by or as if covering over with earth.

2. Use only manufactured fittings in the construction of fire protection, plumbing and HVAC systems. The use of weld-o-lets, pipe saddles, field formed tees, flex hoses, and other non-standard fittings are not allowed without a clear definitive call out in the Specifications.

B. Class B:

1. Pipe and Fittings: CISPI 301, service weight, plain end hubless cast iron soil pipe and fittings.

2. Joints: CISPI 310, no-hub coupling consisting of neoprene gaskets with stainless steel clamps and bolts.

C. Class C:

1. Pipe: ASTM A53, Schedule 40, galvanized, threaded pipes.

2. Fittings: ANSI B16.12, ASTM A74, ASTM D2466, and cast iron recessed drainage type threaded fittings.

3. Joints: Threaded and coupled joints, ANSI B1.20.1.

D. Class D:

1. Pipe:

   a. Three inches and smaller pipe: Polyvinyl chloride ASTM D1784, ASTM D1785, Schedule 40, Type I, Grade 1.

   b. Four inches or larger pipe: Polyvinyl Chloride ASTM D1784, ASTM D2665, standard dimensional ratio (SDR) 26 or thicker, Type 1, Grade 1.

2. Fittings:

   a. Three inches and smaller pipe: ASTM D2467, socket weld, same material and schedule as pipe.

   b. Four inches and larger pipe: ASTM F1336, standard dimensional ratio (SDR) 26, with ASTM F477 Gasket, same material as pipe.

3. Joints:

   a. Three inches and smaller pipe: ASTM D2564 and ASTM D2855, socket welded with ASTM D2564 PVC solvent cement and ASTM F656 primer.

   b. Four inches and larger pipe: Full circumference, grade 316 SS compression band and screw clamps, 12 gauge or heavier with full length neoprene gaskets.

   c. Four inches and larger pipe: ASTM D3034 gasket bell joints with F477 gaskets.

E. Class E:

1. Pipe: ASTM B88, Type K, hard copper tubing.

2. Fittings: ANSI B16.18 cast bronze solder fittings, or ANSI B16.22 wrought copper solder fittings and couplings.

3. Unions: one-half inch to two inches in size, provide cast brass, Class 150, with ground joint, brass to brass seat, and solder ends.

4. Joints: Silver-brazed.

F. Class F:

1. Pipe: ASTM B88, Type L hard copper tubing.

2. Fittings: ANSI B16.18 cast copper or bronze solder fittings, or ANSI B16.22 wrought copper or bronze solder fittings and couplings.

3. Unions: one-half inch to two inches in size, provide cast brass, Class 150, with ground joint, brass to brass seat, and solder ends.

4. Joints: Silver brazed.

G. Class G:

1. Pipe: ASTM B306, Type DWV, copper drainage tubing, of sizes indicated.

2. Fittings: ANSI B16.18 cast copper or bronze solder fittings, or ANSI B16.22 wrought copper or bronze solder fittings and couplings.

3. Unions: Cast copper, brass, or bronze with ground joints and solder ends.

4. Joints: Silver brazed unless soldering indicated on the Contract Drawings.

H. Class H:

1. Pipe: Polyvinyl chloride ASTM D1784 (PVC), ASTM D1785, Schedule 80, Type I, Grade 1.

2. Fittings: ASTM D2466 or ASTM D2467, socket weld, same material and schedule as pipe.

3. Joints: ASTM F656, primer. ASTM D2564 and ASTM D2855, socket welded with PVC solvent cement.

I. Class I:

1. Pipe Ductile iron standard pressure class 350, AWWA/ANSI C150/A21.50 and AWWA/ANSI C151/A21.5. Provide with polyethylene encasement.

2. Fitting: Class 125 or 150 Iron Flanges.

3. Joint: Flanged, grooved, restrained flange or coupling.

J. Class J:

1. Pipe: Pre-insulated piping used for buried insulated refrigeration piping. This shall consist of Type K copper tubing, surrounded by polyurethane foam insulation one inch thick, having a K factor of 0.13 Btu in/hr/ft^2, all surrounded by a jacket of ASTM D1784 PVC of 110 mils thickness.

2. Fittings: Same as for Class E pipe, with insulation and ASTM D1784 PVC jacket to match pipe as specified above.

3. Joints: Silver-brazed.

K. Class K: Four Inches and Larger Pipe:

1. Pipe: AWWA C900, Class 305, DR14, per ASTM D2241 polyvinyl chloride (PVC) pipe with bell and spigot ends and flexible ring joints, meeting requirements of ASTM D2241.

2. Fittings: ASTM D1784, Class 12454-A or Class 12454-B, polyvinyl chloride (PVC) fittings, AWWA C900, Class 305, DR14.

3. Joints: ASTM D3139 gasketed bell joints with ASTM F477 gaskets. Provide stainless steel tie rods and restraining clamps on bell and socket connections. Provide concrete thrust blocks for elbows, tees, valves and appurtenances.

L. Class R: As specified under Class S.

M. Class S:

1. Pipe:

   a. Two and one-half inches and smaller pipe: Schedule 40, Grade A or B, hot dipped galvanized steel pipe.

      1) ASTM A53, Type S or Type E.

      2) ASTM A795, Type S or Type E.

      3) ASTM A106, Type S.

   b. Three inches and larger pipe: Schedule 40, Grade A or B, hot dipped galvanized steel pipe.

      1) ASTM A795, Type S or Type E.

      2) ASTM A135, Type E.

2. Fittings:

   a. Two and one-half inches and smaller: ANSI B16.3, Class 300, banded, galvanized, ASTM A197 malleable iron, ASTM A153/A153M threaded fittings.

   b. Two and one-half inches and smaller: ANSI B16.11, galvanized, ASTM A181/A181M forged steel, Grade E, class 60 or class 70, threaded fittings.

   c. Three inches and larger: Fittings for grooved piping systems shall be manufactured from galvanized ductile iron and comply with ASTM A536, Grade 65-45-12. Nipples shall be manufactured from galvanized ductile iron or galvanized carbon steel, schedule 40 and comply with ASTM A53 type E or S, Grade A or B. Flanges shall be manufactured from galvanized cast iron and comply with ANSI B16.5, Class 150.

3. Joints:

   a. Two and one-half inches and smaller: Threaded.

   b. Larger than Two and one-half inches: Flanged or grooved. Pipe grooves shall be cut or rolled in accordance with coupling manufacturer’s specifications.

4. Unions and Couplings:

   a. Two and one-half inches and smaller: ANSI B16.3, Class 300, banded, galvanized, malleable iron, AAR pattern, threaded with brass or bronze seats.

   b. Larger than Two and one-half inches: Flanged or grooved (end) couplings.

5. Flange Gaskets: Full-face, MIL-G-13120, rubber, 1/16-inch thick.

6. Grooved Couplings:

    a. Provide ASTM A536 galvanized ductile iron, ASTM A47, Grade 32510, or ASTM A197 galvanized malleable iron, grooved couplings rated for 450 psig working pressure. Provide ASTM A183 or ASTM A194/A194M track type bolts for couplings.

    b. Sealing gaskets shall have internal sealing lips projecting diagonally inward so that internal pressure serves to increase tightness of the seal when installed. Gaskets shall be Victaulic Grade E type EPDM, Gustin Bacon Type II butyl, or equivalent synthetic-rubber elastomeric material.

N. Class T:

1. Pipe size three inches and smaller: not used.

2. Pipe size four inches and larger:

    a. Pipe: AWWA C900, Class 305, DR14, per ASTM D2241 polyvinyl chloride (PVC), acceptable for butt-fusion jointing, meeting requirements of ASTM D2241. Fusible PVC pipe shall be extruded with plain ends. The ends shall be square to the pipe and free of any bevel or chamfer. There shall be no bell or gasket of any kind incorporated into the pipe. Fusible PVC pipe shall be manufactured in a standard 40-foot nominal length.

O. Class W:

1. Pipe two and one-half inches and smaller: not used.

2. Pipe size 3-inches and larger:

    a. Ductile iron pipe AWWA C115/A21.15, thickness Class 53 minimum, 250 psi minimum working pressure, grooved end rigid type radius cut conforming to AWWA C606, 250 psi minimum working pressure. Provide standard bituminous exterior coating per ANSI/AWWA C151/A21.51.

3. Fittings:

    a. Grooved End: AWWA C606 and AWWA C110/A21.10, ductile iron, 250 psi minimum working pressure.

    b. Branch connections shall be made by tee fitting, except connections 3 inches and smaller shall be made with service saddles.

4. Couplings:

    a. Grooved End: 250 psi minimum working pressure, malleable iron in accordance with ASTM A47/A47M or ductile iron in accordance with ASTM A536, rigid type.

b. Grooved End Adapter Flanges: 250 psi minimum working pressure, malleable iron in accordance with ASTM A47/A47M or ductile iron in accordance with ASTM A536, with flange rings for conditions where manufacturer instructions require.

c. Provide manufacturer's standard bolting.

5. Gaskets:

a. Gaskets in contact with potable water shall be ANSI/NSF 61 certified.

b. Grooved end: halogenated butyl conforming to ASTM D2000 and AWWA C606 coupling, Victaulic Grade M FlushSeal, Gustin-Bacon or equal.

c. Flange adapters and flange face gaskets Grade "M" Halogenated Butyl. Specifically compounded to conform to ductile pipe surfaces.

6. Coating and Lining:

a. Coating and lining shall be factory applied to pipe, fittings, and couplings. Lining shall be cement mortar in compliance with AWWA C104/A21.4. Materials in contact with potable water shall be certified as meeting the specifications of NFS/ANSI 61. Provide standard bituminous exterior coating per ANSI/AWWA C151/A21.51.gas piping.

2.03 GAS PIPE

A. Buried Piping: Underground natural gas piping shall be provided in accordance with the following requirements:

1. Three inches and smaller Pipe: ASTM D1248, standard specification for polyethylene plastic molding and extrusion materials, Type ll, Class B, Category 5, Grade P24 polyethylene IPS tubing having a PPI hydrostatic design stress rating (HDS) of 630 PSI at 73.4 degrees Fahrenheit. Pipe shall be in accordance with ASTM D2513 and the standard dimensional ratio (SDR) shall be as follows: 7.0 for 1/2 inch, 11.0 for three-fourths inch and one inch, 10 for 1-1/4 inch, 11.0 for two inch, and 11.5 for three inch.

   Note: Straight lengths of two inch and three inch pipe may be substituted for coiled tubing provided the pipe meets the minimum requirements specified herein.

2. 4 inches and larger pipe: ASTM D1248 and ASTM D2513, polyethylene pipe having a PPI HDS of 630 psi at 73.4 degrees Fahrenheit, and having 11.5 SDR.

3. Fittings all sizes: ASTM D2513 and ASTM D2683, polyethylene socket weld, confirming to ASTM 2683.

4. Joints: Socket weld only.

5. Meter Risers: Schedule 40 black steel pipe, epoxy-coated, meeting requirements of ASTM D2513 and D.O.T. 192-283 CSA approved and IAMPO listed, transition riser with double "O" ring seal transition fitting for polyethylene piping connection.

B. Above Grade Piping: Black steel, schedule 80 pipe, with threaded, Class 300 malleable iron fittings and ground joint unions up 2-1/2 inches, and Class 300 flanged for 3 inches and larger pipe, meeting District and jurisdictional authority standards.

2.04 DIESEL EXHAUST PIPE

A. Pipe: Provide factory-built double wall pipe. Outer jacket shall be aluminum coated steel 0.025 inches thick and inner pipe shall be Type 304 or Type 316 stainless steel 0.035 inches thick. Provide air gap of one-inch minimum between pipe and jacket. Pipe shall be laboratory tested, classified, and listed by a nationally recognized testing agency.

B. Fittings: Provide manufacturer's standard fittings and installation accessories for use with specified pipe. Provide special fittings as indicated.

C. Joints: Pipe joints shall be sealed by use of V-bands and high temperature joint cement as recommended by the pipe manufacturer.

2.05 HYDRAULIC PIPING FOR ELEVATORS

A. Provide hydraulic line between elevator machine room and hoistway pits, as indicated. Refer to 14 24 00 Hydraulic Elevators for pipe containment provisions.

1. Pipe: ASTM A53, Schedule 80 seamless, black steel, suitable for minimum 500 pounds per square inch service with a minimum safety factor of three ratio of burst pressure to service pressure.

2. Only line sizes 2 inches and greater are allowed for hydraulic piping.

3. Fittings 2 inches and larger: ASTM A234, and ANSI B16.9, standard weight, butt-welded fittings.

4. Joints 2 inches and larger: Butt-welded. Pipe and fittings should exhibit a 30-degree bevel angle at the welded ends.

5. Unions 2 inches and larger: Flanged.

6. Flanges: ANSI B16.5 and ASTM A181, Grade I, forged raised or insert face, 150-pound class, slip-on or weld neck to suit work site conditions.

7. Grooved couplings and fittings meeting ASME A17.1 requirements where approved may be used as alternative for exposed piping in non-public spaces, machine rooms and pits, or other ancillary facilities. By provisions per ASME A17.1, grooved couplings are allowed only in locations that will permit disassembly and inspection of all their component parts. Gaskets used for grooved joints shall be chemically compatible ("A" or "Excellent" rating) with the hydraulic oil to be used.

B. Provide 1/2 inch diameter hydraulic scavenger (oil return) line between Elevator Machine Rooms and Hoistway Pits, where indicated.

1. Pipe: ASTM A53, Schedule 40, black steel, screwed.

2. Fittings: Threaded, ANSI B16.12, Schedule 40.

2.06 HYDRONIC PIPING AND SPECIALTIES

A. Condensate, Condenser, Heating, and Chilled Water Piping; Buried:

1. Steel Pipe: ASTM A53/A53M, Schedule 40, for 3 inch and larger sized, black with AWWA C105 polyethylene jacket.

   a. Fittings: ASTM A536 black, ductile iron or ASTMS 197 black malleable iron grooved and coupling. All buried fittings to be provided with AWWA C105 Polyethylene jackets.

   b. Joints: Welded.

2. Copper Tubing: ASTM B88/B88M, Type K, annealed for 2-1/2 inch and smaller size.

   a. Fittings: ASME B16.22, wrought copper.

   b. Joints: Solder, lead free, ASTM B32, 95-5 tin-antimony, or tin and silver, with melting range 430 to 535 degrees Fahrenheit.

B. Condensate, Condenser, Heating and Chilled Water Piping; Above Ground:

1. Steel Pipe; ASTM A53/A53M, Schedule 40, grooved ends galvanized 2 1/2 inches and larger.

   a. Fittings: ASTM A395/A395M and ASTM A536 galvanized ductile iron, grooved ends.

   b. Joints: Grooved mechanical couplings meeting ASTM F1476.

      1) Housing Clamps: ASTM A395/A395M and ASTM A536 ductile iron type.

      2) Gasket: Elastomer composition for operating temperature range from 86 degrees Fahrenheit to 230 degrees Fahrenheit.

      3) Accessories: Steel bolts, nuts, and washers.

2. Copper Tubing: ASTM B88 Type K, hard drawn 2 1/2 inches and smaller.

   a. Fittings ASME B16.18, cast brass, solder wrought copper.

   b. Tee Connections: Mechanically extracted collars with notched and dimpled branch tube.

   c. Joints: Solder, lead free, ASTM B32, 95-5 tin-antimony, or tin and silver, with melting range 430 to 535 degrees Fahrenheit.

C. Automatic Air Vent: Designed to vent automatically with float principle; bronze body and nonferrous internal parts; 150 psig working pressure, 250 degree Fahrenheit operating temperature, with 1/4 inch discharge connection and 1/2 inch inlet connection. Provide 1/2 inch ball valve at each air vent to permit service of air vent.

D. Pump Suction Diffusers: Angle or straight pattern, pump inlet fitting, 175 psig pressure rating; cast iron body and end cap. Include bronze start-up and stainless steel permanent strainers; stainless steel straightening vanes; drain plug; and factory fabricated support.

E. Expansion Tank: Provide welded steel expansion tank, size and capacity as indicated. Tank shall be fitted with lifting rings, seismic anchorage and skirt as required. Fitting connections shall be same as for pipe. Provide sight glass. Paint tank with two coats of primer.

F. Air Separator: Provide external air separation unit with integral system strainer as indicated. Strainer shall be removable, of stainless steel, with 3/16 inch diameter perforations, and shall have a free area of not less than five times the cross sectional area of the connecting pipe. Provide seismic anchorage. Provide blow down connection. Paint separator with two coats of primer.

G. Valve Applications: General-Duty Valve Applications: Unless otherwise indicated, use the following valve types:

1. Shutoff Duty: Gate and ball.

2. Throttling Duty: Globe and butterfly valves.

H. Provide welded threadolets for temperature and pressure gages.

I. Provide separable wells and flow switches in accordance with Section 23 09 00, Instrumentation and Control for HVAC. Coordinate sizes and locations with Section 23 09 00, Instrumentation and Control for HVAC.

2.07 BRANCH OUTLETS

A. Refrigeration Piping: Wrought copper tees, Schedule 80, soldered.

B. Copper Tubing: Manufactured brazing Tees, with branch size at least two sizes smaller than the main or cast bronze tees.

C. Threaded, steel piping and socket-weld PVC piping. Provide tees as specified under Article 2.01.

2.08 PIPE JOINT MATERIAL

A. Silver Brazing Alloy: Comply with AWS A5.8 requirements, Class BAg-1 for 1100 degrees Fahrenheit to 1500 degrees Fahrenheit melting temperature.

B. Solder: ASTM B32, Grade 95 TA, up to 250 degrees Fahrenheit.

C. Arc-Welding Electrodes: AWS A5.1 through AWS A5.29, as applicable.

D. Welding Rods for Oxyacetylene Welding: AWS A5.2.

2.09 GASKETS

A. For joints in soil, waste, vent, and drain piping, provide polychloroprene rubber cellular elastomeric preformed gasket and compatible sealing material as required for type of piping material used.

2.10 INSULATING CONNECTIONS

A. For two inches and Smaller Piping: Provide insulating joints that consist of a three-inch minimum length of threaded dielectric nipple pipe and dielectric unions or flanges at both ends. The unions shall be of two dissimilar metal parts with dielectric gasket.

B. For two and one-half inches and Larger Piping: Provide dielectric insulating flanges constructed so that two pipes being connected are completely insulated from each other with no metal-to-metal contact. The flanges shall be galvanized and shall be made up with complete insulating components consisting of a dielectric gasket, bolt insulator sleeves, and bolt washers.

2.11 EXPANSION JOINTS

A. Pressure Rating: 150-psig minimum at 250 degrees Fahrenheit.

B. Type: Flanged, stainless steel, consisting of a corrugated bellows, capable of absorbing pipe movement in an axial or lateral direction. Provide with support rods to keep flange faces parallel during installation.

C. Pipe-Alignment Guides: As recommended by the pipe joint manufacturer but not more than five feet on each side of each expansion joint, except in lines four inches or smaller, they may be not over two feet each side of the joint.

D. Traverse Capacity of Joint: Not less than indicated.

E. Provide 4-way bracing on each side of the joint.

2.12 Y-TYPE STRAINERS

A. Strainer Requirements: Provide strainers full line size of connecting piping, 175 psig WOG pressure rating, with 304 series stainless steel 60 mesh screen, ASTM A126, Class B.

B. Two inches and Smaller: Brass or bronze body, threaded connections, screwed screen retainer, with centered blow down fitting and gate valve of the same size as blow off tapping.

C. Two and one-half inches and Larger: Cast-iron body, flanged connections, bolted screen retainer with off-center blow down fitting and gate valve of the same size as blow off tapping.

2.13 GAGES AND TEST PLUGS

A. Test Plug: At each side, provide a 1/4-inch female NPT adapter for test gages conforming with FS GG-G-76. Provide captive spring-loaded ball check in stainless steel housing with male thread for installation in threaded tee for locations indicated.

B. Gages: Operating range of gages shall be approximately 150 percent of indicated operating service pressure or 200 psig, whichever is greater. Draft gages for HVAC air filter shall be differential type calibrated 0.10 to 1 inch of water column.

1. Calibration: Calibrated to two percent in middle one-third of dial range and equipped with means of front calibration.

2. Movements: Phosphor-bronze bushed, rotary type.

3. Panel Mounted: Flush mounting type in cast iron or aluminum cases.

4. Stem or Pipe Mounted: Flangeless cases of drawn or stamped steel, or aluminum.

C. Pressure-Differential Gages: Draft gages for HVAC air filter banks shall be pressure differential type with a calibrated range of 0.10 to 1 inch of water column.

2.14 THERMOMETERS

A. Requirements: Thermometer case, stem and bulb chamber will be constructed of die cast aluminum. Protective lens material should be either shatter proof glass or polycarbonate. A high magnification glass tube filled with non-toxic colored liquid shall be used. The scale will have a maximum of two degrees between graduations and 20 degrees between figures. The scale range shall be 150 percent of the normal operating process temperature of the system with an upper limit of 300 degrees Fahrenheit. A brass separable socket shall be provided.

B. Scale Lengths: Seven inches minimum for tanks and similar equipment, and five inches minimum for piping.

C. Optional: Provide dial thermometer with five inch dials and liquid-filled thermal systems.

2.15 ACCESS DOORS AND PANELS

A. Access Requirements: Provide manufactured or prefabricated wall and ceiling access panels for service access to equipment and valves. Comply with requirements of Section 08 31 00, Access Doors and Panels. For access doors and panels in sheet metal ductwork and plenums, refer to Section 23 31 00, HVAC Ducts and Casings, for requirements.

B. Size: Large enough to permit removal of equipment, but not less than 12 inches by 12 inches net opening. Where entrance of service person is required, provide minimum opening of 24 inches by 24 inches.

C. Construction: Refer to Section 08 31 00, Access Doors and Panels, for requirements.

2.16 PIPE SLEEVES

A. Pipe sleeves and seals shall comply with applicable requirements of Section 20 20 13, Pipe Sleeves, Supports and Anchors for Facility Services.

2.17 CASINGS

A. Casing Requirements: Provide minimum black steel pipe conforming to ASTM A53, Schedule 40, with polyethylene encasement in accordance with AWWA C105.

B. Casing Insulators: High-density, injection-molded polyethylene casing insulator having the following properties:

1. Compressive strength (ASTM D695)	3200 psi
2. Tensile strength (ASTM D638, ASTM D651)	3100 - 5500 psi
3. Water absorption (ASTM D570)	0.1 percent
4. Impact strength (ASTM D256)	1.5 to 4.0 ft-lb/in. of notch

C. Casing End Seals:

1. Provide modular type mechanical casing seals consisting of interlocking synthetic rubber links shaped to fill the annular space between the pipe and casing and nonconductive pressure plates, with stainless steel compression bolts (T-head type) and nuts. Seals shall be sized in accordance with the manufacturer’s requirements for the particular size of carrier pipe and casing involved to obtain a watertight seal and withstand indicated test pressure for casing.

2. Modular type mechanical seals for metallic carrier pipe inside a metallic casing shall be an insulating type designed to provide electrical isolation between the carrier pipe and casing.

2.18 VALVES

A. Approved Valves: For wet standpipe and fire protection sprinkler systems, valves shall be listed and approved by nationally recognized agencies for intended service and shall bear stamp or label of the agency. The main isolation valve shall be located inside the building at the utility entrance and shall be an OS&Y valve.

B. Gate Valves:

1. Two inches and Smaller in Diameter: 150 pound, bronze body, bronze trim, rising stem, wedge disc, union bonnet, threaded connection, conforming with requirements of MSS SP-80.

2. Two and one-half inches and Larger in Diameter: 125 pound, except 175 pounds for use on wet standpipe and fire protection sprinkler systems, cast iron body, bronze trim, bolted bonnet, rising stem, solid wedge disc, hand wheel, outside screw and yoke, flanged connection, provide chain wheel operators for valves six inches and larger mounted eight feet above floor, conforming with requirements of MSS SP-70.

C. Globe Valves:

1. Two inches and Smaller in diameter: 150 pound (except 175 pound for use on fire protection systems), bronze body, bronze trim, rising stem, EDPM disc, bronze disk holder, screw bonnet, threaded connection, conforming with requirements of MSS SP-80.

2. Two and one-half inches and Larger in Diameter: 125 pound, except 175 pounds for use on wet standpipe and fire protection sprinkler systems, cast iron body, bronze trim, rising stem, plug-type disc, flanged connection, provide chain wheel operators for valves six inches and larger mounted eight feet above floor, conforming with requirements of MSS SP-85.

D. Swing Check Valve:

1. Two inches and Smaller in Diameter: 150 pound, bronze body and cap, bronze seat, bronze threaded connection, with removable stainless steel hinge pin and screwed cap, suitable for operation in either horizontal or vertical position. Conform to requirements of MSS SP-80.

2. Two and one-half inches and Larger in Diameter: 125 pound, cast iron body, Y-pattern, flanged connection with removable stainless steel hinge pin and bolted cap, cast iron disk, flanged end. Conform to requirements of MSS SP-71.

3. Fire Protection Use: Spring-loaded swing check valve with grooved ends, cast-iron body, stainless-steel seat, hinge pin, spring and clapper, and elastomeric seal, suitable for horizontal or vertical installation, and 250 psig working pressure.

E. Butterfly Valves: 150 pound except fire protection 300 psi wwp, body of ductile iron conforming to ASTM A395 and MSS SP-67, equipped with ASTM A582/A582M, stainless steel stem, EPDM encapsulated ductile iron disc, and EPDM “0” ring stem seals. The valve shall be assembled complete with a valve supervisory switch and a stem extension assembly. The stem extension shall have a hand crank and a reflectorized disc indicating valve disc position.

1. Where bronze valves are indicated or required, provide valves conforming to FS WW-V-1967.

F. Angle Hose Valves: Cast brass conforming to ASTM B62, rated for 300-psig non-shock service. Valves shall have fire department hose thread on discharge site, female NPT inlet, and shall be equipped with union bonnet, replaceable composition disc, and bronze stem. Hose valves shall be furnished with cast-bronze cap with chain attached to cap and valve, except the 1-1/2 inch angle hose valves installed in fire hose cabinets shall be connected to fire hose.

G. Air Release Valves: Cast-iron body with 300 series stainless-steel and bronze trim, combination air release and vacuum breaker type suitable for 300 psig working pressure.

H. Valve Supervisory Switch: Provide for post indicator valves, butterfly valves, and OS&Y gate valves for Fire Protection service only. Switches shall be mounted so as not to interfere with the normal operation of the valve and shall be adjusted to operate within two revolutions of the valve control or when the stem has moved no more than one-fifth of the distance from its normal position. The mechanism shall be internal in the gear operator of butterfly valve or contained in a weatherproof die cast metal housing that shall provide a 1/2-inch conduit entrance and incorporate the necessary facilities for attachment to the valve. The switch mechanism shall have a minimum rated capacity of 10 amps at 125/250 volts AC and 2.5 amps at 24 volts DC. The entire installed assembly shall be tamper-resistant.

I. Calibrated Plug Valves: 125 psig working pressure, 250 degree Fahrenheit maximum operating temperature, bronze body, plug valve with calibrated orifice. Provide with connections for portable differential pressure meter with integral check valves and seals. Valve shall have integral pointer and calibrated, scale to register degree of valve opening. Valves two-inch and smaller shall have threaded connections; valves two and one-half -inch and larger shall have flanged connections.

J. Balancing Flow-Control Valves: Pressure independent Class 150, cast-iron housing, stainless- steel operating parts; threaded connections for two-inch and smaller, flanged connections for two and one-half -inch and larger. Factory set to automatically control flow rates within plus or minus five percent design, while compensating for system operating-pressure differential. Provide quick disconnect valves for flow measuring equipment. Provide metal identification tag with chain for each valve, factory marked with the zone identification valve model number and flow rate.

K. Triple-Duty Valves: Angle or straight pattern; 175 psig pressure rating; cast iron body; pump discharge fitting. Include drain plug, bronze-fitted shutoff, balancing and check valve features.

L. Pressure-Reducing Valves: MSS SP-80 valves two inches and smaller shall be all bronze construction meeting requirements of MSS SP-80. MSS-SP-85 valves two and one-half inches and larger shall be all cast iron construction meeting requirements of MSS SP-70. Valves two and one-half inches and smaller shall have threaded connections. Valves three inches and larger shall have flanged connections. Valves shall be stainless steel spring-loaded, single-seated, and suitable for tight shutoff under dead-end conditions. Provide with renewable stainless steel seat, nylon inserted diaphragm, and bolted spring chamber. Valves shall be rated for 300 psi working pressure, adjustable from 25 to 75 psi, factory set at 50 psi. Pressure gauges (or gauge ports) shall be installed upstream and downstream of the pressure-reducing valve.

M. Safety Relief Valves:

1. AGA Z21-22 and ASME BPVC Section IV, pressure and temperature relief valves shall be AGA design certified, ASME listed and rated, with bronze body, brass trim, stainless steel spring and silicone rubber seat disc. Pressure and temperature valves shall be installed on all water heaters and hot water storage tanks, rated for heating capacity of water heater.

2. Valves shall be ASME rated for intended service, and shall be single-seated, bronze body and trim, stainless steel spring, adjusting screw with cap and threaded connections for two and one-half inches and smaller valves, and flanged connections for three inches and larger valves.

N. Ball Valves: Two inches and Smaller: MSS SP 110, 400 pound one piece bronze body, chrome plated brass ball, regular port, teflon seats, blow-out proof stem, threaded ends with union.

O. Plug Valves: Two inches and Smaller: MSS SP 78, 150 pound, semi-steel construction, round port, full pipe area, pressure lubricated, teflon packing, threaded ends. Furnish one plug valve wrench for every ten plug-valves with minimum of one wrench.

PART 3 – EXECUTION

3.01 INSTALLATION REQUIREMENTS

A. Protection of the Work:

1. Cover openings in ductwork, conduits, and piping, and temporarily seal openings to protect from contamination.

2. Protect materials and equipment from damage due to environmental conditions. Use protective cover, and protect from surface water by using raised platforms.

3. Protect unfinished work at the end of each workday from damage, contamination, and moisture by the use of plugs, caps, and covers, as applicable.

4. Protect piping and valves from damage pending performance of systems tests.

5. Protect installed thermometers and gauges from accidental damage by construction activity.

6. Following installation, and before final embedment, provide temporary protective covers and fixtures to prevent damage from traffic and overburden loads that may damage or displace embedments.

7. Clean fixtures, piping, valves, finished brass, and equipment installed under this work. Drain and flush piping to remove grease and foreign matter. Flush air and gas piping with compressed dry nitrogen.

B. Locations of Fixtures and Equipment:

1. The mechanical sheets of the Contract Drawings are diagrammatical and not intended for use in determining the exact locations of the components of mechanical and electrical systems.

2. Refer to applicable sheets of the Contract Drawings to determine the exact locations of fixtures and equipment to be installed as well as the locations of items or equipment indicated to be installed by others.

C. Provide seismic restraints, bracing, and anchors for piping and equipment in accordance with the requirements of Section 20 30 13, Vibration Isolation and Seismic Control for Facility Services.

D. Provide pipe sleeves, supports, and anchors in accordance with Section 20 20 13, Pipe Sleeves, Supports, and Anchors for Facility Services.

3.02 INSTALLATION OF PIPING

A. Install piping parallel to walls, floors, and ceilings, unless indicated otherwise. Clear obstructions, preserve headroom, and keep openings and passageways clear.

B. Ream pipe and tube ends. Remove burrs.

C. Remove scale and dirt, inside and outside, before assembly.

D. Remove welding slag and foreign material from pipe and fitting materials.

E. Should structural features or other work prevent running of pipes or setting of equipment at locations indicated, minor deviations will be permitted, as approved by the Engineer.

F. Run piping in chases or recesses in walls where provided, through openings in floors, and in furred ceilings; otherwise, as exposed pipes. Do not embed piping in or below the structure, except as indicated.

G. Expanding or swaging of tubing to fit IPS fitting sockets will not be permitted.

H. Provide reducing fittings where change in pipe size occurs. Reducing bushings shall not be used unless otherwise indicated.

I. Provide couplings only where required pipe runs between fittings are longer than standard length of pipe being used.

J. Make changes in direction only with manufactured fittings.

K. Provide expansion loops (bends) where indicated.

L. Provide proper length bolts for each size flange on flanged connections. Bolts with excessive length of exposed threads will not be permitted. A minimum of three full threads is required to be exposed beyond the nut after tightening the assembly.

M. Prevent entry of foreign matter during handling, assembling, and installation. Use compressed air, wire brush, solvent, and other acceptable means to remove scale, dirt, and other foreign matter from interior of piping before final connections are made. Protect open ends of pipe by capping, plugging, or by other acceptable methods.

N. Anchor piping subject to expansion or contraction in a manner permitting such strains and stresses to be evenly distributed and alleviated by swing joints or expansion loops.

O. Provide unions or flanges in piping connections to equipment.

P. Install piping with sufficient pitch to ensure proper drainage and venting.

Q. Make exposed polished or enameled piping connections to fixtures or equipment to avoid damage to finished surfaces. Knurled pipe wrenches shall not be used on chrome-plated or polished stainless steel or aluminum tubing or equipment.

R. Electrically isolate connections between piping of dissimilar metals, between District-owned and non-District-owned piping, where pressure piping enters any structure not more than five feet from point of entry inside the structure, and where indicated.

S. Install class of piping as indicated. Pressure pipe will not be permitted under concrete structures and building floor slabs.

T. Do not run water piping over electric switchboards, transformers, or electric motor starters.

3.03 INSTALLATION OF HYDRONIC PIPING AND SPECIALTIES

A. Hydronic Piping Valve Installation:

1. Install shutoff-duty valves at each branch connection to supply mains, at supply connections to each piece of equipment, and elsewhere as indicated.

2. Install throttling-duty valves at each branch connection to return mains, at return connections to each piece of equipment, and elsewhere as indicated.

3. Install calibrated balancing valves on the outlet of each heating or cooling element, and elsewhere as required to facilitate system balancing.

4. Install drain valves at low points in mains, risers, branch lines, and elsewhere as required for system drainage.

5. Install check valves on each pump discharge and elsewhere as required to control flow direction, unless triple-duty valves are indicated.

6. Install safety relief valves on hot water boilers and elsewhere as required by ASME Boiler and Pressure Vessel Code. Pipe discharge to floor without valves. Comply with ASME BPVC Section VIII, Division 1, for installation requirements.

B. Hydronic Piping Installation:

1. Install piping as specified in this Section.

2. Locate groups of pipes parallel to each other, and provide space to permit applying insulation and servicing of valves.

3. Install drains at low points in mains, risers, and branch lines consisting of a tee fitting, three-fourths inch NPS ball valve, and short three-fourths inch NPS threaded nipple and cap.

4. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

5. Reduce pipe sizes using eccentric reducer fittings installed with level side up.

6. Install branch connections to mains using tee fittings in main with takeoff out from bottom of main line, except for up-feed risers with takeoff out from top of main line.

7. Install unions in pipes two inch NPS and smaller, adjacent to each valve, at final connections of each piece of equipment and elsewhere as indicated. Unions are not required at flanged connections.

8. Install flanges on valves, apparatus, and equipment having 2-1/2 inch NPS and lager connections.

9. Install flexible connectors at inlet and discharge connections to pumps (except inline pumps) and other vibration-producing equipment.

10. Install strainers on supply side of each control valve, pressure-reducing valve, pressure-regulating valve, solenoid valve, in-line pump, and elsewhere as indicated. Install three-fourths-inch NPS nipple and ball valve in blow-down connection of strainers two inch NPS and larger.

11. Anchor piping to ensure proper direction of expansion and contraction.

12. Install welded threadolets for temperature and pressure control.

C. Hydronic Specialties Installation:

1. Install automatic air vents at high points in system, heat-transfer coils, and elsewhere as required for system air venting.

2. Install dip-tube fittings in boiler outlet. Run piping to expansion tank with a two percent upward slope toward tank. Connect boiler-outlet piping.

3. Chemical Feeders: Provide valved connections for chemical feeders. Permanent chemical feeders will be furnished by others. Provide temporary equipment for injection of initial chemical charge.

4. Install expansion tanks as indicated. Vent and purge air from hydronic system, and charge tank with proper air charge to suit system design requirements.

D. Terminal Equipment Connections:

1. Install control valves in accessible locations close to equipment.

2. Install bypass piping with ball or butterfly valve around control valve. Where multiple, parallel control valves are installed, only one bypass is required.

3. Install pressure gage at coil inlet connections.

E. Testing:

1. Use ambient temperature water as testing medium.

2. Use vents installed at the high points of system to release trapped air while filling system. Use drains installed at low points for complete removal of liquid.

3. Examine system to ensure that equipment and parts that cannot withstand test pressures are properly isolated. Examine test equipment to ensure that it is tight and that low-pressure filing lines are disconnected.

4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the design pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Check to verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times “SE” value in Appendix A of ASME B31.9.

5. After hydrostatic test pressure has been applied for at least ten minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components as appropriate, and repeat hydrostatic test until there are no leaks.

6. Prepare and submit written report of testing.

F. Adjusting and Cleaning:

1. After completing system installation, including outlet fittings and devices. inspect finish. Remove burrs, dirt, and construction debris, and repair damaged finishes including chips, scratches, and abrasions.

2. Fill the piping system with water and remove air. Flush each circulating system with an alkaline cleaning solution to remove grease and oil in the piping system. Solutions using trisodium phosphate shall be heated to temperatures of 160 degrees Fahrenheit to 180 degrees Fahrenheit. Other solutions may be submitted for approval. Drain and rinse with clean water.

3. Fill the piping system and remove air. Flush each circulating system with and acid cleaning solution to remove rust and scale. Apply solutions in accordance with manufacturer's instructions. Drain and rinse with clean water.

4. Remove, clean, and replace strainer screens. After cleaning and flushing hydronic-piping system, but before balancing, remove disposable fine-mesh strainers in pump suction diffusers. Fill the piping system and remove air. Charge systems with initial chemical treatment as follows:

    a. Heating, pH control, scale inhibitor, corrosion inhibitor, and conductivity controller.

5. Mark calibrated nameplates of pump discharge valves after hydronic system balancing has been completed, to permanently indicate final balanced position.

G. Commissioning:

1. Fill system and perform initial chemical treatment.

2. Check expansion tanks to determine that they are not air bound and that system is full of water.

3. Perform the following before operating the system:

    a. Open valves to fully open position. Close coil bypass valves.

    b. Check pump for proper direction of rotation.

    c. Set automatic fill valves for required system pressure.

    d. Check air vents at high points of systems, and determine that all are installed and operating freely (automatic type).

    e. Set temperature controls such that coils are calling for full flow.

    f. Check operation of automatic bypass valves.

    g. Check and set operating temperatures of boilers, chillers, and cooling towers to design requirements. Comply with requirements of Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.

    h. Lubricate motors and bearings.

3.04 INSTALLATION OF PIPE JOINTS AND CONNECTIONS

A. Installation Requirements:

1. Provide tool specifically designed for pipe cutting; debur all cut pipe ends. Make joints leak-tight. Test and remake leaky joints with new materials. Thread cement or calking shall not be used to remake leaky joints.

2. Do not use a sharp-toothed wrench in making up brass pipe or chrome-plated items.

3. Thread and length of threads shall be in accordance with applicable ANSI standards. Use a thread lubricant on male threads suitable for the proposed pipe service.

4. Soldered joints, ends of pipe, and insides of fittings shall be thoroughly cleaned and polished. Uniformly heat joint, and ensure capillary space is completely filled with solder, leaving a full bead of solder around the entire circumference of the joint.

5. Clean PVC pipe end with cleaning agent in accordance with manufacturer's recommendations.

6. Welded pipe joints, qualification of welders, and testing shall be performed in accordance with AWS B21.3 or ASME Section VIII.

7. Provide a gasket coated with the gasket manufacturer's recommended lubricant between the contact faces of the flanges.

8. Install hubless cast iron pipe, fittings, and joints in accordance with CISPI 301.

B. Copper Tubing Systems:

1. Use non-toxic silver-brazed joints for services specified. Flow nitrogen through tubing to prevent oxidation during brazing.

2. Where soldering service is specified, make joints with 95-5 tin-antimony (SN95, SN94, E) solder per ASTM B32.

3. Clean outside of tube and inside of fitting at point of contact with fine grit carborundum sandpaper to a bright finish without deposits before joining. Take care to prevent over-heating of tube and fitting before joining. Before silver brazing, disassemble solder type valves used in refrigerant piping, and keep valve bodies cool by use of damp cloths or other approved methods.

4. The use of copper compression type fittings shall not be acceptable. Copper connections shall be threaded, soldered, or brazed only.

C. Steel Pipe and Welding Fittings:

1. Make joints in welded piping by oxyacetylene or electric arc process with welding continuous around pipe. Use qualified welders and welding procedures as specified in AWS B2.1.

2. Hydraulic piping welding shall use gas tungsten arc weld (GTAW) to root pass, using AWS ER70S-2 or ER70S-6 filler metal with argon purge. Shield metal arc weld (SMAW) the remaining weld to completion with AWS E7018 low hydrogen electrodes. Metal gas welding will not be permitted on hydraulic lines.

3. Welded branch outlets on galvanized steel pipe shall be cleaned of weld splatter, and all surfaces in the vicinity thereof shall be wire brushed and coated with a zinc rich painting system having a three mil DFT as specified in Section 09 91 00, Painting.

D. Polyvinyl Chloride (PVC) Pipe:

1. Threaded Joints: Make joints with Teflon pipe joint compound, or Teflon tape of type recommended by pipe and fitting manufacturer, suitable for service where it is to be used, conforming to ANSI B1.20.1.

2. Flanged Joints: When required, flanged joints may be used to connect to equipment or to other piping materials. Provide flanged, socket type molded PVC heavy-duty, 150-pound pattern, drilled in accordance with ANSI B16.5.

3. Socket Welded Joints: Use solvent cement of type recommended by the fitting manufacturer, suitable for service where it is to be used. Joints shall be made by workers skilled in technique of welding PVC pipe.

4. Fusible PVC

   a. Unless otherwise specified, fusible PVC pipe lengths shall be assembled in the field with butt-fused joints. The Contractor’s written and submitted procedure shall follow the pipe supplier’s guidelines. Only appropriately sized and outfitted fusion machines that have been approved by the pipe supplier shall be used for the fusion process. Fusion machines shall include heat plate, carriage, and data logging devices, in good condition and supplied by appropriate power.

   b. Joint: Each fusion joint shall be recorded and logged by an electronic monitoring device (data-logger) connected to the fusion machine. The fusion data-logging and joint report shall be generated by software developed specifically for the butt-fusion of PVC thermoplastic pipe. The software shall register or record the parameters required by the pipe supplier and these specifications. Data not logged by the datalogger shall be logged manually and be included in the fusion technician’s joint report.

   c. Bead Removal: Fusion bead within casing pipe and exterior of carrier pipe shall be removed prior to inserting carrier pipe into casing. Removal of the fusion bead shall be conducted with proper bead removal equipment and be completed by the fusion technician per the manufacturer’s recommendations.

E. Steel Pipe and Grooved Couplings:

1. Flexible Couplings: Provide flexible grooved couplings for all piping systems routed through subway and U-wall trainway sections.

2. Rigid Couplings: Provide rigid grooved couplings for piping at all other locations as approved by the Engineer.

F. Diesel Exhaust Pipe: Install as indicated and in accordance with the pipe manufacturer's installation instructions.

3.05 INSTALLATION OF UNIONS, FLANGES, AND GASKETS

A. Unions: Provide unions where indicated and at each threaded or soldered connection to equipment, tanks, and valves, with the following exceptions:

1. Provide three unions at each three-way valve.

2. Only one union is required at each manually operated threaded valve.

3. In refrigerant piping systems, provide only where indicated.

B. Locations of Unions: Locate unions such that piping can be easily disconnected for removal of equipment, tank, or valve.

C. Flanges: Provide matching flange faces at each connection to equipment, tanks, and valves. Install gaskets of the required types.

3.06 INSTALLATION OF FLEXIBLE PIPE CONNECTIONS

A. Align and space piping accurately before installation. Do not use flexible connections to correct misalignment.

B. Support piping near equipment to prevent weight of pipe from compressing or extending flexible connection from required installed setting.

C. Install flexible connection as recommended by the connection manufacturer.

D. Assemble flexible section with metal retaining rings, built-in braided wire, built-in reinforcement with restriction bolts, or with wire-braid cover. Equip flanged assemblies with limit bolts to restrict maximum travel.

E. Provide control units for pipe connectors at equipment mounted on vibration isolators, to limit travel.

F. Provide pipe guides on each side of each expansion joint as recommended by the joint manufacturer. Provide four-way bracing on each side to maintain expansion capacity.

G. For expansion joints, provide joints with welded, flanged, or threaded ends, and bases for each joint unless otherwise indicated. Provide single-element joints with bases as an end anchor where indicated. Provide ball joints of stainless steel, malleable iron, ductile iron, carbon steel, bronze, or other alloys suitable for the service intended. Pre-compress expansion joints at time of installation in accordance with manufacturer's installation instructions; and as required by actual temperature of pipe at time of installation.

3.07 INSTALLATION OF GAGES

A. Requirements: Provide gages or test connections where indicated.

B. Labels: Install flexible aluminum-faced, black-plastic-backed indicating plate, three-fourths inch by three inches, with service engraved into black backing. Labels shall be mounted to gage body with stainless steel rivets.

C. Gage Cocks: Provide at each gage connection.

D. Gage Siphon: Install a gage siphon at each hot water gage.

3.08 INSTALLATION OF THERMOMETERS

A. Location and Type: Install thermometers to be easily read by a person standing on the floor of the room. Use straight, angle, or remote types to suit installation conditions.

B. Thermometers for Measuring Liquid Temperatures:

1. Install with extension necks or stems to suit insulation on pipes or the lining of tanks.

2. Install so bulb projects into flow stream and is completely immersed in liquid.

C. Labels: Install flexible aluminum-faced, black-plastic-backed indicating plate, three-fourths inch by three inches, with service engraved into black backing. Labels shall be mounted to gage body with stainless steel rivets.

3.09 INSTALLATION OF ACCESS DOORS AND PANELS

A. Required Locations: Provide access panels wherever valves, damper operators, fire dampers, gages, and similar items requiring servicing, adjustment, and inspection are concealed. Access panels are not required in furred or suspended ceilings with removable ceiling panels.

B. Door and Panel Types:

1. In Acoustical Tile Ceilings: Provide fill-in type, installed integral with tile pattern. Fill in with ceiling tile.

2. In Fire-Rated Ceilings: Provide fire-rated access panel, fill-in type or flat-faced, flush mounted panel as required.

3. Other Locations: Provide flat-faced flush mounted panel.

4. Provide plaster frame and grounds for plaster ceilings and walls.

C. Interface and Coordination: Refer to Section 08 31 00, Access Doors and Panels, for additional requirements.

3.10 INSTALLATION OF VALVES AND VALVE BOXES

A. Requirements: Provide valves at points indicated and specified, arranged to give complete and regulating control of piping systems. Provide valves full size of line, unless otherwise indicated. Install valves with neat appearance and grouping, so all parts are easily accessible for operation and maintenance. Install throttling flow valves where indicated, and on each circulating return branch on domestic hot water systems, on hot water heating systems, and on chilled water systems. Provide valve boxes for exterior valves for protection.

B. Stop Valves: Install stop valve or a compression stop on water supply lines to each plumbing fixture, including faucets and showers. Where required for accessibility, install them exposed adjacent to faucets. Where fixture trim is specified with integral built-in stops, individual supply stops will not be required. Union end fitting or union shall be installed downstream of stop valve.

C. Install valves with stems upright or horizontal, not inverted.

D. Install gate valves for shut-off and isolating service, to isolate equipment, part of system or vertical risers.

E. Provide drain valve at main shut-off valves and at low points of piping and apparatus.

F. Air Vent Valves: Manual Air Vent Assemblies: Provide where indicated and at high points to free piping system of air. Connect one-fourth inch copper tubing to top of high point, or other location, and extend down to easily accessible one-fourth-inch globe valve, mounted approximately five feet above floor, grouped and tagged. Discharge through one-fourth inch copper tubing to nearest floor drain or as approved by the Engineer.

G. Automatic Type Air Vent Valves: Provide and install as indicated with full sized copper tubing drain line from automatic valve to nearest floor drain or as approved by the Engineer.

H. Pressure Reducing Valves: Install reducing stations along walls or other available spaces with arrangement to permit easy access for servicing and removal of equipment. Provide union of flanged joints to permit springing pipe for valve removal. Provide a three-valve bypass at each pressure-reducing valve.

I. Chain Operators: Provide chain operators for valves, four inches and larger located overhead, seven feet or more above floor.

3.11 INSTALLATION OF PIPE AND VALVE IDENTIFICATION

A. Provide in accordance with Section 20 40 13, Identification for Facility Services.

3.12 INSTALLATION OF EQUIPMENT

A. Place equipment in locations and spaces indicated. Move equipment into spaces through openings as required. Disassemble and reassemble equipment or other work necessary to accomplish this work.

B. Provide platforms and hangers as required for the installation of equipment.

C. Mount equipment on vibration isolation units, concrete inertia blocks, or concrete pads as indicated and in accordance with the approved Shop Drawings.

D. Install, align, and adjust equipment and vibration isolators in accordance with the respective manufacturer's installation instructions and recommendations.

E. Provide mechanical equipment where indicated with V-belts and cast-iron machined and balanced V-groove sheaves. Key sheaves to shafts and lock with setscrews. On electric motors size NEMA 48 and smaller, fasten sheaves with hardened knurled cup point set screws against flat surface on shaft.

3.13 INSTALLATION OF FUSIBLE PVC

A. Pipe shall be fused prior to insertion, if the Jobsite and conditions allow, into one continuous length. Pipe shall be installed in location after pull-back operations, unless otherwise authorized by Engineer.

B. Fusion bead within casing pipe and exterior of carrier pipe shall be removed prior to installation. Removal of the fusion bead shall be conducted with proper bead removal equipment and be completed by the fusion technician per the manufacturer's recommendations.

C. Pipe shall be handled in a manner that will not over-stress the pipe prior to insertion. Vertical and horizontal curves shall be limited so that the pipe does not bend past the pipe supplier's minimum allowable bend radius, buckle, or otherwise become damaged. Damaged portions of the pipe shall be removed and replaced.

D. The pipe entry area shall be graded as needed to provide support for the pipe, and to allow free movement into the installation location.

E. The pipe shall be guided into the bore hole to avoid deformation of, or damage to, the pipe. The fusible PVC pipe may be continuously or partially supported on rollers or other approved friction decreasing implement during joining and insertion, provided the pipe is not over-stressed or critically abraded prior to, or during, installation.

F. In pulling applications, a swivel shall be used between the reaming head and the fusible PVC pipe to minimize torsion stress on the pipe assembly.

G. Buoyancy modification shall be at the Contractor's sole discretion and shall not exceed the pipe supplier's guidelines with regard to maximum pull force or minimum bend radius of the pipe. Damage caused by buoyancy modifications shall be Contractor's responsibility.

H. Once pull-back operations have commenced, the operation shall continue without interruption until the pipe is completely pulled through the bore hole.

I. The pipe shall be installed in a manner that does not cause upheaval, settlement, cracking, or movement and distortion of surface features. The Contractor shall correct any damages caused by Contractor's operations.

3.14 PAINTING

A. Except where otherwise indicated, piping systems, ductwork, and HVAC equipment shall not be painted. Where pipes, ductwork, and HVAC equipment are indicated to be painted, such as exposed items in finished rooms, prepare and paint as specified in Section 09 91 00, Painting. Copper, brass, bronze, and stainless items shall not be painted.

END OF SECTION 20 10 13

SECTION 20 20 13

PIPE SLEEVES, SUPPORTS, AND ANCHORS FOR FACILITY SERVICES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Pipe sleeve.

B. Pipe hangers, supports, and guides.

C. Anchors and anchorage devices.

D. Seismic requirements.

1.02 RELATED SECTIONS

A. Section 05 05 22, Metal Welding.

B. Section 05 50 00, Metal Fabrications.

C. Section 20 10 13, Common Materials and Methods for Facility Services.

D. Section 20 30 13, Vibration Isolation and Seismic Control for Facility Services.

1.03 MEASUREMENT AND PAYMENT

A. Separate measurement or payment will not be made for the work required under this Section. All costs in connection with the Work specified herein will be considered to be included or incidental to the Work of this Contract.

1.04 REFERENCES

A. American Society of Mechanical Engineers (ASME):

1. ASME B31.1 Power Piping
2. ASME B31.2 Fuel Gas Piping
3. ASME B31.9 Building Service Piping Code
4. ASME B36.10 Welded and Seamless Wrought Steel Pipe

B. American Society for Testing and Materials (ASTM):

1. ASTM A36/A36M Specification for Carbon Structural Steel
2. ASTM A53 Specification for Pipe, Steel, Black and Hot Dipped, Zinc Coated Welded and Seamless

3. ASTM A74 Specification for Cast Iron Soil Pipe Fittings
4. ASTM A153/A153M Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
5. ASTM A307 Specification for Carbon Steel Bolts and Studs, 60 000 psi Tensile Strength
6. ASTM A449 Specification for Quenched and Tempered Steel Bolts and Studs
7. ASTM A563 Specification for Carbon and Alloy Steel Nuts
8. ASTM F708 Practice for Design and Installation of Rigid Pipe Hangers

C. Federal Specifications (FS):

1. FF S 325 Shield, Expansion; Nail, Expansion; and Nail, Drive Screw (Devices, Anchoring, Masonry)
2. WW H 171 Hangers and Supports, Pipe

D. Manufacturers Standardization Society (MSS):

1. MSS SP-58 Pipe Hangers (Clevis Type) and Supports − Materials, Design and Manufacture
2. MSS SP-69 Pipe Hangers (Clevis Type) and Supports – Selection and Application
3. MSS SP-89 Pipe Hangers (Clevis Type) and Supports – Fabrication and Installation Practices

E. National Fire Protection Association (NFPA):

1. NFPA 13 Installation of Sprinkler Systems
2. NFPA 14 Installation of Standpipe and Hose Systems

F. State of California, Department of Transportation (Caltrans):

1. Standard Specifications, Section 75, Miscellaneous Metal

G. Sheet Metal and Air Conditioning Contractor’s National Association, Inc. (SMACNA):

1. Seismic Restraint Manual Guidelines for Mechanical Systems

H. Underwriters Laboratories Inc. (UL):

1. UL 203 Pipe Hanger Equipment for Fire Protection Service
2. UL 1479 Fire Tests of Through-Penetration Firestops

1.05 REGULATORY REQUIREMENTS

A. Refer to Section 20 10 13, Common Materials and Methods for Facility Services – Fire Suppression, Plumbing and HVAC, for requirements.

1.06 SUBMITTALS

A. Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Submit Shop Drawings and manufacturers' product data of pipe sleeves, pipe supports, and anchorage devices. Show detailed dimensions and description of materials and parts on drawings or cuts.

1.07 QUALITY ASSURANCE

A. Requirements:

1. Welding Qualifications: Qualify welding processes and welding operators in accordance with Section 05 05 22, Metal Welding.

    a. Certify each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification.

2. Reference Standards: Comply with applicable requirements of the herein listed reference standards.

3. Regulatory Requirements: Comply with California Plumbing Code pertaining to product materials and installation of supports and anchors.

4. NFPA Compliance: Hangers, Clevis Type only, and supports shall comply with NFPA 13 and NFPA 14 including Appendices when used as a component of a fire protection system.

5. Seismic Conditions: Calculations of seismic loading shall be in accordance with the SMACNA Seismic Restraint Manual Guidelines for Mechanical Systems.

B. Criteria for Selection of Pipe Sleeves:

1. Sleeves Through Interior Walls, Floors, and Ceilings: Provide galvanized steel pipe sleeves with welded steel plate anchors.

2. Sleeves Through Exterior Below Grade Walls, Floors, and Ceilings:

    a. Sleeves More Than 15 Feet Below Grade: Provide cast iron sleeves with compression seals.

    b. Sleeves 15 Feet or Less Below Grade: Provide steel sleeve with modular link seals.

3. Sleeves Through Exterior Above Grade Roofs: Provide one of the following:

    a. Lead flashing sleeve or copper sleeve with skirt.

    b. Cast iron sleeve with flashing clamp device, pressure ring, and accessories.

C. Criteria for Pipe Supports, Hangers, Guides, and Anchors:

1. Provide hot dipped galvanized steel clevis type pipe hangers and supports suitable for the usage in accordance with these specifications.

2. Provide pipe hangers and supports suitable for the indicated usage in accordance with FS WW-H-171.

3. Provide pipe hangers of same size, or nearest manufactured size available, as pipe or tubing for which they shall be used, except for insulated piping as specified below.

4. Hangers and supports shall support weight of five times the water filled pipe plus 250 pounds, fluid and pipe insulation, plus the weight of valve and fitting action on the pipe.

5. Provide pipe guides to prevent horizontal or vertical displacement of piping.

6. Provide anchors and support piping and as specified, including seismic restraints.

D. Criteria for Location of Pipe Supports and Hangers:

1. Vertical spacing: Guide and support vertical piping in the center of each riser, but not over ten feet on centers, unless otherwise indicated, and at the base of the riser on a base elbow or tee with pipe stand. Provide riser clamp in accordance with FS WW H 171 and MSS SP-69, type eight (note spacing at each landing in stairwells). For uninsulated copper pipe or tubing, use nonferrous or electrolytically coated steel compatible hangers for the riser clamp.

2. Horizontal spacing:

    a. Provide maximum hanger and support spacing, on centers, for horizontal piping as follows, unless indicated otherwise:

Type of Pipe	Pipe Diameter		
	3/4 in. or smaller	1 in. thru 1-1/4 in.	1-1/2 in. or larger
Steel pipe	8 ft.	10 ft.	10 ft.
Copper tubing	5 ft.	8 ft.	10 ft.
Cast iron pipe in 5 ft. lengths			5 ft.
Cast iron pipe in 10 ft. lengths			10 ft.

b. Place a hanger close to point of change of direction of a pipe in either a horizontal or vertical plane.

3. Place supports and hangers for cast iron soil pipe as close as possible to joints and, when hangers or supports do not come within one foot of a branch line fitting, install an additional hanger or support at fitting.

4. Supports for fire protection piping shall comply with applicable NFPA requirements.

E. Allowable Deviation from Accepted Location: Locate pipe sleeves and pipe support and anchorage devices not more than a half inch from locations indicated on reviewed and accepted Shop Drawings.

1.08 SITE CONDITIONS

A. Do not drill, cut, burn, or weld structural members in connection with the installation of pipe supports, bracing, and anchorage devices, unless proposed in writing and approved by the Engineer.

PART 2 – PRODUCTS

2.01 PIPE SLEEVES

A. Sleeves Through Interior Walls, Floors, and Ceilings:

1. Sleeves: Pipe shall be standard weight conforming with ASTM A53 or ASME B36.10. Steel plate anchor conforming with ASTM A36/A36M shall be welded to pipe. The assembly shall be hot dip galvanized after fabrication.

2. Fire Rated Packing: Where pipes pass through fire rated walls, floors, or ceilings, provide UL listed through penetration fire stop material meeting UL 1479 to seal the opening between the pipe and pipe sleeve and maintain the fire rating.

3. Escutcheons:

    a. Public Areas: Solid plate stainless steel with satin finish.

    b. Non-Public Areas: Split ring chrome plated with set screws.

    c. Size: Minimum one-inch annulus shall be provided except at building seismic joints. Building seismic joint pipe sleeves shall be minimum of five inches greater than the nominal diameter of the pipe.

B. Sleeves Through Exterior Below Grade Walls, Floors, and Ceilings:

1. Sleeves more than 15 feet below grade: Cast iron, ASTM A74, pressure sealing with membrane clamp; cast iron body with external fins, internal steel compression rings and nitrile rubber grommets, and pressure clamp with 18 8 stainless steel bolt. Sealing members shall provide electrical isolation between carrier pipe and all metallic components of sleeve including membrane and pressure clamps.

2. Sleeves 15 feet or less below grade: Steel pipe sleeve, ASTM A53, pressure sealing with membrane clamp ring, gasket, water stop ring, external rings, nitrile rubber link seals. The assembly shall be hot-dip galvanized after fabrication.

    a. Seals: Modular mechanical type seals, consisting of interlocking nitrile rubber links shaped to continuously fill the annular space between the pipe and the sleeve and electrically isolate the carrier pipe from the steel sleeve.

    b. Sealing Element: Polychloroprene rubber material compounded to resist aging, ozone, sunlight, hydrocarbon gases, water, and chemical action.

    c. Hardware: Type 300 series stainless steel fasteners. Threads rolled to produce smooth uniform threads and unbroken flow lines.

    d. Compression Plates: Fiberglass-reinforced polyester plastic, injection molded for high physical properties, dielectric strength and non-cold flow creep characteristics, having high resistance to acidic and alkaline soils.

C. Sleeves Through Exterior Above Grade Roofs: Provide one of the following flashing types as applicable to installation conditions:

1. Lead flashing sleeve weighing four pounds per square foot, or copper sleeve weighing 16 ounces per square foot, suitably framed with skirt extending not less than eight inches.

2. Cast iron sleeve with calking recess, anchor lugs, flashing clamp device, and pressure ring with brass bolts.

2.02 PIPE HANGERS, SUPPORTS, AND GUIDES

A. Provide pipe hangers, pipe supports, and pipe guides hot dip galvanized unless otherwise indicated. Provide copper-plated hangers for uninsulated copper rigid tubing. Provide felt lined hangers or felt or elastomeric wrap on uninsulated copper rigid tubing.

B. Hangers and support components shall be factory-fabricated materials designed and fabricated in accordance with MSS SP-89, MSS SP-58, and MSS SP-69.

1. Components shall have hot dipped galvanized coating; electroplate is not acceptable.

2. Pipe hangers and supports shall have non-metallic felt or elastomeric liner or wrap applied to the pipe for electrolytic protection where hangers and supports are used to support copper tubing or pipe. The liner or wrap shall be designed to allow expansion or contraction of the piping.

3. Strap type hangers shall not be used on any piping system; use only clevis type. The clevis hanger fastener nuts shall be nylon lock type or the standard nut threads shall be coated with a District approved adhesive; untreated nuts are not allowed to be used.

4. Band type or strap type hangers (MSS 5, 7, 9, and 10) shall not be used on any piping system.

C. Provide hot dipped galvanized steel pipe alignment guides, factory fabricated of cast semi-steel or heavy steel and consisting of a two-section bolted outer cylinder and base with two-section guiding spider that bolts tightly to the pipe. Length of guides shall be as recommended by manufacturer to allow six-inch minimum travel in either direction.

D. Anchors for equipment, duct and pipe hangers and supports shall be either of the following types as applicable to installation condition:

1. Cast in Place; Hot dipped galvanized metal inserts or anchor bolts cast into the concrete at time of placing.

2. Post installed; Where inserts or anchor bolts are omitted, post-installed anchor bolts may be used subject to limitations below;

   a. All post-installed anchor bolts shall have International Code Council, ICC, evaluation/approval documentation and be either hot dip galvanized or stainless steel for exterior use conditions.

   b. All post-installed anchor bolts shall be installed in accordance with manufacturer’s instructions.

   c. Only mechanical anchors shall be used in support of sustained tension load conditions.

   d. Where there is presence of train induced vibration and air pressure, or support of vibratory equipment, undercut anchor or anchors with documented fatigue test report shall be used.

   e. All drop-in anchor bolts are prohibited.

E. Types of Hangers:

1. Hangers for Cold Pipe: Carbon steel, adjustable, clevis.

2. Hangers for Hot Pipe Sizes two to four inches: Carbon steel, adjustable, clevis (MSS type 1).

3. Hangers for Hot Pipe Sizes 6 inches and Larger: Adjustable steel yoke, cast iron roll clevis (MSS type 1, 36, 38, 40, 41, 43-46 or 49).

4. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.

5. Vertical Support: Steel riser clamp (MSS type 3, 4, or 8).

6. Copper rigid tubing Support: Carbon steel rings, adjustable, copper plated (MSS type 6).

7. Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded. Connections to threaded rod shall be double nutted.

8. Inserts: Malleable iron case or galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms. Size inserts to suit threaded hanger rods.

2.03 ANCHORS AND ANCHORAGE DEVICES

A. Anchors and Bolts: Bolts and studs, shall conform with A260 or A493, as applicable. Nuts shall conform to ASTM F524 and washers shall conform to ASTM A240, A260 or 493 as applicable. Bolts and studs, nuts and washers shall be AISI Type 316 stainless steel.

B. Fasteners and Accessories: Provide anchors and fasteners, washers, straps, and accessories required for a complete and finished installation. Fasteners shall be AISI Type 316 stainless steel.

C. Expansion Bolts: Where anchors are not included in the concrete or masonry construction, anchors shall be AISI Type 316 stainless steel screws or bolts with expansion-shield type concrete or masonry anchors, of sizes and types indicated or required. Obtain District approval through the Engineer for use of drilled expansion-type anchors before using them in the Work.

2.04 SEISMIC REQUIREMENTS

A. Seismic bracing, anchorages and reinforcements shall be provided for all piping. Equipment and piping shall be anchored to withstand forces generated by earthquake movement.

B. All piping shall be seismically braced, as a minimum as follows:

1. At all changes in direction provide transverse and longitudinal braces.

2. Provide transverse braces maximum of 40 feet on center.

3. Provide longitudinal braces maximum of 80 feet on center.

4. Provide lateral bracing at all end of line sprinklers.

C. Braces shall consist of components specifically designed for intended service, galvanized (except pipe hanger in contact with copper rigid tubing) and complete with galvanized pipe chord member.

D. For piping suspended or supported on trapeze, clamp pipes rigidly to trapeze and brace trapeze in accordance with NFPA 13 requirements, or use engineered system. All material shall be galvanized or stainless steel.

E. The use of wire, rope, strap, chain, wood or similar make shift devise is prohibited. The use of restraint system is prohibited.

PART 3 – EXECUTION

3.01 REQUIREMENTS

A. Install pipe sleeves, pipe supports, guides, and anchorage devices where indicated or required.

B. Examine substrates and conditions where supports and anchors are to be installed. Do not proceed with installation until unsatisfactory conditions have been corrected.

C. Rigidly secure pipe sleeves, pipe supports, guides, and anchorage devices against displacement by concrete placement operations.

D. Protect pipe, valve, hydrants, equipment, etc. from damage from vehicles, trains, etc. As a minimum provide bollard protection where necessary.

3.02 INSTALLATION OF PIPE SLEEVES

A. General Requirements:

1. Provide a pipe sleeve where each pipe passes through an exterior or interior wall, floor, ceiling, or roof, and at other locations indicated.

2. Set pipe sleeves parallel to the pipes that pass through them.

3. Do not install sleeves in structural members except where indicated or approved.

4. Secure sleeves to concrete forms to prevent displacement during placing of concrete.

B. Sleeves Through Interior Walls, Floors, and Ceilings:

1. Install permanent sleeves of steel pipe with steel plate anchors.

2. Where specified sleeves cannot be installed, such as at connections to floor drains, provide sleeves modified to suit installation conditions.

3. Do not allow sleeves or pipe to be in contact with reinforcing steel.

4. Cut pipe sleeves through walls flush with the finished wall surfaces. Sleeves through interior floors shall project three inches above and below the finished floor.

5. Provide minimum of one inch annulus (radial clearance between pipe or pipe plus insulation or coating) to accommodate installation of seal.

6. Where pipes pass through fire rated walls, floors, and ceilings, install linked, preformed double silicone seals with zinc plated pressure plate and bolts. Caulk both sides with UL listed fire seal (expansion foam) fire rated penetration seals in the opening between the pipe and pipe sleeve.

7. Where pipes pass through non fire rated walls, floors, and ceilings, provide lined, preformed EPDM seal with Type 316 plate bolts and pressure plate.

C. Sleeves Through Exterior Below Grade Walls, Floors, and Ceilings:

1. Sleeves more than 15 feet below grade:

   a. Install a cast iron sleeve with compression seals.

   b. Install the sleeve assembly and seals so that there is complete electrical isolation between the carrier pipe and all metallic components of the sleeve including membrane and pressure clamps.

2. Sleeves 15 feet or less below grade:

   a. Install a steel sleeve with modular link seals.

   b. Seal the annular space between the sleeve and pipe with insulating type modular link seals. Assemble the links loosely with bolts to form a continuous rubber belt around the pipe with a compression plate under each bolt head and nut. After the seal assembly is positioned in the sleeve, tighten the bolts so that the sealing elements expand providing electrical isolation between the pipe and sleeve and a hydrostatic seal.

3. Provide sufficient radial clearance beyond pipe, or pipe plus coating, to accommodate installation of sealing elements.

4. Extend exterior coating on buried piping flush with exterior surface of sealing element at outer membrane clamp.

5. Calking or other types of mastic or lead and oakum joints are not acceptable for exterior below grade penetrations.

D. Sleeves Through Exterior Above Grade Roofs: Install copper flashing sleeves, or cast iron sleeves in accordance with manufacturer's instructions.

3.03 INSTALLATION OF PIPE HANGERS AND SUPPORTS

A. Requirements: Provide above ground piping systems inside and outside buildings with anchorages, sway braces, guides, supports, and seismic protection. Support components shall be compatible. Hangers and supports for piping systems shall include the following requirements:

1. The necessary hangers and supports, including beam and purlin clamps, rods, pipe rolls, angles, channels and plates, and any changes from indicated design, shall be approved by the Engineer before installation.

2. Use of building structural steel for supporting hangers will not be permitted unless indicated or approved by the Engineer. Refer to Article entitled "Installation of Anchors" herein for prohibition of drilled anchors in post-tensioned decks.

3. Support vertical piping with approved steel brackets to prevent swaying, sagging, vibration, and resonance; however, allow for thermal expansion between supports or anchors.

4. The use of wire, rope, strap, chain, wood, or similar makeshift devices is prohibited.

5. Hose faucets, compressed air outlets, and similar fixtures at ends of pipe branches shall be supported within three inches.

6. Supporting structures, including supporting frames, anchors, and guides common to mechanical work and electrical work, may be used at Contractor's option, unless otherwise indicated.

7. When piping to equipment is mounted on vibration isolators, provide spring cushion or other approved type isolation hanger on the nearest pipe support and on each side of the equipment.

8. Except as otherwise noted, use clevis type hangers for all pipe sizes. The clevis hanger fastener nuts shall be nylon lock type or the standard nut threads shall be coated with a District approved adhesive; untreated nuts are not allowed to be used. Where copper tubing is directly supported, use copper plated hangers.

9. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.

10. Provide field fabricated, heavy-duty steel trapezes fabricated from steel shapes selected for loads required and welded in accordance with applicable requirements of Section 05 05 22, Metal Welding.

11. Support fire protection systems piping independently from other piping systems.

12. Provide lateral bracing at end of line sprinklers. Restraint system is prohibited.

B. Supports for Insulated Piping:

1. For insulated hot and cold water lines, unless otherwise indicated, use insulation inserts as required for supporting piping from exterior of insulation.

2. Pipe less than two inches may be supported from insulation with galvanized steel half round protective shields.

3. For vertical piping four inches and larger, provide angle or plate type insulation supports welded to pipe at approximately 12 foot intervals. Fabricate these supports of same material as pipe that they are attached to, and of widths less than thickness of insulation covering.

4. Install hangers around outside of low temperature insulation. Insert section of one-inch long by 180 degree cellular glass, minimum eight pounds per cubic foot density, with vapor barrier jacket plus 18 gauge by 10 inch by 180 degree galvanized steel shield. Special hangers equipped with equivalent insulating material and vapor barrier may be used.

C. Supports for Embedded Piping: Provide supports for piping to be embedded in concrete.

3.04 INSTALLATION OF ANCHORS

A. Anchors and anchorage devices shall be accurately located and installed to template furnished by the equipment manufacturer.

B. Provide all bolt heads and nuts with washers.

C. Expansion bolts shall be installed in snug fitting smoothly drilled holes in accordance with the bolt manufacturer’s installation instructions. Expansion bolts shall be installed so that the load acts on the bolts in shear and withdrawal. Expansion bolts shall be carefully located in order to eliminate the risk of damage to concrete, steel reinforcement, and other embedded items.

D. Bolted connections shall be retightened before final acceptance or, in the case of bolted connections in concealed locations, immediately before the area is sealed off.

E. Installation of drilled anchors into post-tensioned decks will not be permitted.

END OF SECTION 20 20 13

SECTION 20 30 13

VIBRATION ISOLATION AND SEISMIC CONTROL FOR FACILITY SERVICES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Vibration isolation devices.

B. Supports.

C. Plumbing and HVAC piping vibration dampeners.

D. Seismic control restraints.

E. Seismic control for piping.

F. Seismic control for ductwork.

G. Vibration insulation.

1.02 RELATED SECTIONS

A. Section 20 10 13, Common Materials and Methods for Facility Services – Fire Suppression, Plumbing and HVAC.

B. Section 20 20 13, Pipe Sleeves, Supports and Anchors for Facility Services.

C. Section 20 30 14, Seismic Performance Requirements for Equipment.

1.03 MEASUREMENT AND PAYMENT

A. Separate measurement or payment will not be made for the work required under this Section. All costs in connection with the Work specified herein will be considered to be included or incidental to the Work of this Contract.

1.04 REFERENCES

A. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE):

1. ASHRAE Handbook, HVAC Systems and Equipment

2. ASHRAE Handbook, HVAC Applications

B. National Fire Protection Association (NFPA):

1. NFPA 90A Standard for the Installation of Air Conditioning and Ventilating Systems

C. Sheet Metal and Air Conditioning Contractors National Association Inc. (SMACNA):

1. SMACNA Seismic Restraint Manual Guidelines for Mechanical Systems

2. SMACNA Duct Construction Standards - Metal and Flexible

D. California Code of Regulations (CCR):

1. Title 24, Part 3 California Electrical Code

E. BFS Introduction, Common Requirements – Trackway Clearance

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit Shop Drawings showing isolator types and sizes, locations with static and dynamic load on each location, and installation details, including recording and alarm device wiring and control diagrams where required.

C. Product Data: Submit manufacturer's product data and certificates of compliance for each type of vibration control product provided.

D. Maintenance Data: Submit maintenance data for each type of vibration control product, and include in maintenance manual specified in Section 01 78 23, Operation and Maintenance Data.

E. Seismic Calculations: Submit seismic calculations on all equipment, ductwork and piping restraints, anchors and supports. Calculations shall be prepared by a civil or structural engineer currently registered in the State of California and shall conform to BART Facilities Standards Structural – Seismic Design Criteria.

F. Measured Equipment Deflections: Upon completion of vibration control work, prepare a report showing measured device deflections for each major item of equipment indicated.

1.06 MANUFACTURER RESPONSIBILITIES

A. The Contractor shall arrange with the manufacturers of the vibration isolation and seismic control devices to provide the following services along with the specified equipment and control devices:

1. Determine vibration isolation and seismic restraint device sizes and locations.

2. Provide piping, ductwork and equipment isolation systems, and seismic control systems as indicated.

3. Guarantee specified isolation system deflection.

4. Provide installation instructions and drawings.

5. Provide resilient restraining devices as required to limit equipment and piping motion in excess of one fourth inch as approved by the Engineer.

6. Calculations of seismic loading and design for seismic conditions shall be in accordance with applicable referenced standards and BART Facilities Standards Structural – Seismic Design Criteria.

1.07 QUALITY ASSURANCE

A. The determination of static, dynamic, and seismic loadings and the design of brackets, supports, connections, restraints and other structural elements shall be performed by a civil or structural engineer currently registered in the State of California.

B. The Contractor shall arrange with the manufacturer to provide field services in accordance with the requirements of Section 01 43 00, Quality Assurance.

PART 2 – PRODUCTS

2.01 VIBRATION ISOLATION DEVICES

A. Provide vibration isolation devices for limiting transmittance of vibration from vibration-producing equipment to the structure on which it is supported or attached. Isolate piping and ductwork from rotating equipment with flexible connections.

B. Provide the types of vibration isolation devices as recommended by the respective mechanical equipment manufacturers, to isolate vibrations for each particular piece of equipment.

C. Provide vibration isolation devices consisting of standard rubber pads or one half inch thick neoprene rubber pads between the mounting feet or bracket and the support surface for the following items:

1. Fans and air handling units, roof type unit;

2. Condensing units;

3. Unit heaters;

4. Pumps;

5. Air compressors;

6. Emergency generators;

7. Elevator motors, motor generators, dc power converters, and hydraulic power units; and

8. Electrical equipment containing reactors or choppers.

D. Provide spring isolators and inertia pads for fans, pumps, and other vibrating equipment, that is located, directly above or adjacent to an occupied area. Provide rubber pads one half inch thick between the spring foot and the support surface. Spring isolators shall be the seismic restraining type.

E. Isolator types, base types, and minimum static deflection shall be in accordance with ASHRAE Handbook, HVAC Applications, and Chapter 43. Vibration Isolator Selection guide, unless otherwise indicated.

2.02 SUPPORTS

A. Concrete Bases: Ventilation fans of 25 hp or greater or engine generators of 300 hp or greater shall be mounted on concrete inertia bases (pads) with isolation units to support equipment. Provide rectangular structural beam channel or complete sheet metal box forms for floating foundations. Provide frame unit as indicated, or if not indicated, provide frame with minimum depth of six inches. Provide reinforcing both horizontally and longitudinally butt welded to the base framing.

B. Equipment Frames:

1. Provide mounting frames and brackets for fans, pumps, and compressors to carry the load of the equipment without causing mechanical distortion or stress to the equipment.

2. For wide flange structural steel frames with brackets, the maximum allowable deflection of any point on the loaded frame relative to the unloaded frame is 0.005 inch. A wide flange section with a depth greater than one tenth of the length of the longest frame member is acceptable for satisfying deflection requirements.

3. For channel structural steel frames with four-point support, the section depth requirement is the same as that specified above in Article 2.02.B.2.

2.03 PLUMBING AND HVAC PIPING VIBRATION DAMPENERS

A. Type 1: Closed spring hanger with one-inch thick acoustic isolator.

B. Type 2: Elastomer mount with threaded insert and hold down holes.

C. Type 3: Trisolators - Steel metal sleeve with felt insert to be installed at attachment points of hangers or piping.

2.04 SEISMIC CONTROL RESTRAINTS

A. Requirements:

1. Restraints shall permit adjustment during installation to ensure sufficient clearance between vibration isolated element and rigid restraining device.

2. A restraint shall not be installed until vibration isolators have been loaded and adjusted to achieve the specified static deflection and clearance.

3. Restraints at base supported equipment shall include resilient neoprene pads at all potential contact areas between isolated equipment and rigid restraining element.

B. Description:

1. Restraining devices at all base supported vibration isolated equipment may be separate components sized and installed to meet the requirements specified or may be built into vibration isolation mounts.

2. Piping to vibration-isolated equipment shall have vibration isolation joints and isolator type seismic restraints. The isolator type seismic restraints shall, as a minimum, consist of steel rods, three eighths inch minimum diameter together with neoprene snubbers arranged to achieve the required all-directional restraint anchored and sized to resist the seismic forces as specified above. Shop Drawings shall indicate proposed method for achieving vertical restraint for ceiling suspended piping. Rods shall have sufficient slack to avoid short-circuiting the vibration isolators.

2.05 SEISMIC CONTROL FOR PIPING

A. Longitudinal and transverse seismic bracing of all piping, including plumbing piping, fire protection piping, sewer piping, and storm drain piping, shall be installed in accordance with Section 20 20 13, Pipe Sleeves, Supports, and Anchors for Facility Services.

2.06 SEISMIC CONTROL FOR DUCTWORK

A. Longitudinal and transverse seismic bracing of all ductwork shall be installed in accordance with SMACNA Seismic Restraint Manual Guidelines for Mechanical Systems and ASHRAE Handbook, HVAC Applications, Chapter 50, except that the design of restraints shall be based on a force equal to 100 percent of the weight of the ductwork acting in either direction.

2.07 VIBRATION ISOLATION

A. All piping, electrical conduit, and ductwork shall be isolated from the equipment to which they are attached.

B. Ductwork isolation shall be by means of physical three-inch gap with flexible fabric connections furnished and installed in accordance with SMACNA Duct Construction Standards - Metal and Flexible and ASHRAE Handbook, HVAC Systems and Equipment, Chapter 16. Flexible fabric connections shall conform to NFPA 90A. Fabric shall be unpainted glass fiber cloth weighing not less than 32 ounces per square yard. Cloth shall be coated with fire-resistant neoprene on both sides. Flexible portion shall be six-inches long. Perimeter connection on each end shall be three-inch-wide galvanized sheet steel, and shall be mechanically bonded to the

fabric. Fasteners shall be either screws or bolts. Flexible connectors shall be mechanically secured, at both ends, to provide airtight joints.

C. Piping isolation shall be by means of flexible connector furnished as follows:

1. For system pressure of 60 to 250 psig: Provide stainless steel below hose assembly complete with bellows with stainless steel woven wire mesh jacket and stainless steel nipple ends, threaded for piping two inches and smaller, flanged, 250 pounds for piping two and a half inches and larger. The bellow hose assembly shall be rated for 450 pounds operating pressure at 120 degrees Fahrenheit.

2. For system pressure less than 60 psig: Provide woven nylon or polymer reinforced neoprene or BUNA A corrugated or bellows-type flexible connector with integral flanges, 125-pound drilling. Unit shall be rated for minimum 125-pound drilling. Unit shall be rated for minimum 125 psig operating pressure.

3. For refrigerant lines: Provide stainless steel or copper bellows assembly with woven stainless steel wire mesh jackets rated for refrigerant service, 12-inch minimum length overall.

4. For electrical conduit: Provide three-foot length seal tight flexible conduit in accordance with applicable requirements of the California Electrical Code.

PART 3 – EXECUTION

3.01 INSPECTION

A. Examine location and installation conditions where vibration-control units are indicated to be installed. Do not proceed with work until unsatisfactory conditions, if any, have been corrected.

3.02 PERFORMANCE OF ISOLATORS

A. Comply with minimum static deflections recommended by ASHRAE referenced standards for selection and application of vibration isolation materials and units as indicated.

B. Except as otherwise indicated, comply with manufacturer’s instructions and recommendations for selection and application of vibration isolation materials and devices.

3.03 APPLICATIONS

A. Product Selection: Except as otherwise indicated, select vibration control products as specified in Article 2.01. Where more than one type of product is offered that meet specified requirements, the selection is the installer’s option.

B. Piping: For piping connected to equipment mounted on vibration control products, install isolation hangers as indicated that provide static deflection of the first point to be twice the deflection of the isolated equipment and as follows:

1. For the first three points of support for pipe sizes four inches and smaller.

2. For the first four points of support for pipe sizes five inches through eight inches.

3. For the first six points of support for pipe sizes 10 inches and larger.

C. Seismic Control Restraints: Provide seismic restraints in accordance with referenced SMACNA Seismic Restraint Manual Guidelines for Mechanical Systems.

3.04 INSTALLATION

A. Install vibration isolation and seismic restraint devices as indicated. Provide for installation on a level base.

B. Set steel bases for one-inch clearance between housekeeping pad and base. Adjust equipment level.

C. Use an anchor-bolt location template for proper alignment between concrete pad, anchor base, vibration isolation device, and bolt holes on base of apparatus being supported. Provide anchor bolts with washers and hex nuts Torque nuts to manufacturer's recommended setting.

D. Schedule of Piping Isolators:

1. Horizontal lines, four inches and larger: Spring hanger, Type 2, nominal two inches static deflection.

2. Horizontal lines, two inches to four inches: Spring hanger, Type 1, nominal one-inch static deflection. Hanger boxes shall be mounted directly against building structural members, and not on slab diaphragm.

3. Horizontal lines, one half inch to one and a half inches: Type 3 Trisolator sleeves with felt insert in sheet metal jacket.

4. Vertical risers, pipe clamp with applicable isolators: Single point of support shall be provided for risers greater than four inches in diameter at highest point. Guide at midpoints of riser shall be provided with neoprene mounts. Submit detail of guide and support.

5. Pipe anchors, vertical or horizontal: Resilient anchor points shall be installed in piping to provide a neutral point for expansion and contraction of piping without direct contact of piping with building structure.

E. Where anchor bolts pass through the rubber support pads, provide a neoprene rubber sleeve and washer to separate the anchor bolt shank and head (or nut) from the machine support foot or bracket.

F. Provide a pair of neoprene side snubbers or restraining springs where side torque or thrust may develop.

3.05 ADJUSTING AND CLEANING

A. Clean each vibration and seismic control unit, and verify that each is working freely and that there is no dirt or debris in the immediate vicinity that could possibly short-circuit unit isolation.

3.06 START-UP

A. Before start-up of equipment, check level of equipment or apparatus as required. Start up and check for proper deflection of vibration isolation devices. Make necessary adjustments.

END OF SECTION 20 30 13

SECTION 20 30 14

SEISMIC PERFORMANCE REQUIREMENTS FOR EQUIPMENT

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Seismic requirements for design, testing, and installation of equipment.

1.02 DESCRIPTION

A. Equipment indicated as necessary to remain operable during and after a seismic event, or specified with a Component Importance Factor 1.5, shall meet the seismic requirements specified in this Contract Specifications Section, including equipment supports (which include raceways, hangers, anchorages, mountings and attachments), except equipment supports that have been fully designed and detailed on the Contract Drawings.

B. The requirements specified herein are in addition to seismic requirements specified elsewhere in these Contract Specifications. Where other Contract Specifications Sections require design or installation conforming to regulatory standards or codes such as California Building Code (CBC), or Sheet Metal and Air Conditioning Contractors National Association (SMACNA) publications, it shall be done using not less than the site-specific seismic parameters specified in Article 1.07A, herein.

1.03 RELATED SECTIONS

A. Section 20 30 13, Vibration Isolation and Seismic Control for Facility Services

B. Section 20 70 26, Common Materials and Methods for Electrical Systems

C. Section 20 72 25, Factory and Field Testing

D. Section 20 80 00, System Integration Testing

E. Section 23 13 23, Above Ground Fuel Storage Tanks

F. Section 26 05 17, Dry-Type Transformers

G. Section 26 05 70, Electrical Cabinets and Enclosures

H. Section 26 12 16, Medium Voltage Transformers

I. Section 26 18 42, Medium Voltage (4.16KV) Metal Clad Switchgear

J. Section 26 18 43, Emergency Generator Switchgear House (SGH)

K. Section 26 24 13, Switchboards

L. Section 26 24 22, Motor Starters and Contactors

M. Section 26 24 24, Circuit Breakers and Panel Boards

N. Section 26 28 15, Low Voltage Disconnect and Transfer Switch

O. Section 26 32 13, Engine Generators

P. Section 26 33 01, DC Battery System

Q. Section 26 34 37, Uninterruptible Power Supply (UPS)

R. Section 27 13 01, Communication Cables and Related Equipment

S. Section 27 60 00, Monitoring and Control System

1.04 MEASUREMENT AND PAYMENT

A. Separate measurement or payment will not be made for work required under this Contract Specifications Section. All costs in connection with the work specified herein will be considered to be included with the related items of work in the Bid Schedule of the Bid Form, or incidental to the Work.

1.05 REFERENCES

A. California Code of Regulations (CCR):

1. CCR Title 24, Part 2, California Building Code (CBC)

B. American Society of Civil Engineers (ASCE):

1. ASCE 7 Minimum Design Loads for Buildings and Other Structures

C. American Concrete Institute (ACI):

1. ACI 318 Building Code Requirements for Structural Concrete and Commentary

2. ACI 530 Building Code Requirements for Masonry Structures

D. International Code Council Evaluation Service (ICC-ES):

1. AC156 Acceptance Criteria for Seismic Certification by Shake-Table Testing of Nonstructural Components

E. International Organization for Standardization (ISO):

1. ISO 17025 General requirements for the competence of testing and calibration laboratories.

F. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE 693 Recommended Practice for Seismic Design of Substations

G. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):

1. Seismic Restraint Manual Guidelines for Mechanical Systems

1.06 SUBMITTALS

A. Submittals shall be in accordance with Section 01 33 00, Submittal Procedures.

B. Shop Drawings: Submit complete Shop Drawings including anchorage and base plate settings.

C. Test certification from manufacturer that demonstrates component is seismically qualified by shake table testing meeting Section 1.07 specified herein.

D. Special seismic certification test plan(s) for new or additional tests. Test plans for new or additional tests shall be submitted and approved prior to performing the tests. Test plan (s) shall include pre and post seismic-testing functional compliance verification procedures.

E. Test reports of new or additional tests showing conformance with the requirements specified herein, prepared and stamped by a professional Civil or Structural Engineer in the State of California.

F. Supporting data showing equipment is inherently rugged, where allowed herein.

G. Certificates of Compliance for Seismic Certification with the requirements specified herein, sealed by a professional Civil or Structural Engineer registered in the State of California.

H. Structural Calculations: Submit structural design calculations of the equipment support components and their anchorage to demonstrate adequacy of the system under the design loads specified in the CBC and Article 1.07 herein. Calculations shall be prepared and sealed by a professional civil or structural engineer registered in the State of California. The special inspection and test requirement of the equipment support including its anchorage shall be specified in the structural design calculations.

I. Special Inspection Report: Submit special inspections report performed by independent testing agency for equipment seismic qualification inspection and support anchorage installations.

1.07 SEISMIC PERFORMANCE REQUIREMENTS

A. Meet the requirements of ASCE 7 with the following site-specific seismic parameters:

1. Seismic Design Category D, E or F

2. Component Importance Factor, $I_p = 1.5$

3. Design earthquake spectral response acceleration parameter at short period, S_{DS}, determined in accordance with ASCE 7.

4. Height Factor Ratio, z/h, determined in accordance with ASCE 7. Where the location of the installed equipment is at or below grade, z/h = 0 may be used. Where the location of the installed equipment is undefined, z/h = 1 shall be used.

B. For equipment other than traction power equipment, meet the Special Certification Requirements for Designated Seismic Systems in ASCE 7, with the following additional requirements:

1. Active or energized equipment shall be certified exclusively on the basis of shake table testing in accordance with AC156, performed by an independent laboratory having accreditation to ISO 17025. Use of experience data is not an acceptable alternative to shake table testing. The following components may be exempted from shake table testing, provided their supports and attachments are shown by calculations to be in accordance with ASCE 7 and CBC using the seismic design parameters specified above:

    a. Equipment and components weighing not more than 50 lbs. supported directly on structures and not mounted on other equipment or components.

    b. Pipes, ducts, conduits, cables, cable trays, and raceways, excluding in-line equipment and components.

    c. Where it can be shown that the component is inherently rugged by comparison with similar seismically qualified components. Submit shake table test reports of similar equipment or experience data per ASCE 7 Section 13.2.6 to show the equipment is inherently rugged. Support and attachment calculation are still required for rigid component.

2. As required by AC156, the configuration of mounting to the shake-table shall simulate the actual service mounting conditions for the product. The flexibility of the supporting structure in the component to point of anchorage shall be replicated in the test setup; alternatively, the input motions for the test setup may be modified to account for this flexibility using a rational analytical method. See Section 4.5.2 of AC156. If anchorage used for shake table testing differs to field installed anchorage, verify that the shear and tensile capacities of test anchors are less than or equal to actual fasteners to be used for final field installation of component.

3. To qualify a product line, shake-table tests of representative specimens of that product line may be used in lieu of testing each specific model of equipment to be used in service. A minimum of two representative equipment/components shall be tested for a product line with similar structural configuration, provided the mounting configurations simulate the actual service mounting conditions for the product. If the smallest/lightest and largest/heaviest representative equipment/components are selected for testing, it shall be shown that these provide the least seismic capacity when compared to other options that are available within the product line being qualified. See Section 4.5 of AC156 for further requirements for qualifying equipment product lines.

4. Functionality testing: The equipment shall be functionally tested pre- and post-seismic testing, to demonstrate that the essential operational and control features of the equipment needed for post-earthquake functionality are maintained. The essential operational and control features of the equipment shall be identified in advance of the shake-table testing, including the functionality testing methods and functionality acceptance criteria.

5. The shake table test input shall be based on the following parameters as defined in AC 156:

   a. $A_{FLX-H} = S_{DS}$

   b. $A_{RIG-H} = 0.4\ S_{DS}$

   c. $A_{FLX-V} = 0.67\ S_{DS}$

   d. $A_{RIG-V} = 0.27\ S_{DS}$

C. Notify Engineer at least 4 weeks advance-notice of shake table test date for the observation of test setup and testing.

D. For traction power equipment follow requirements of IEEE 693, Recommended Practice for Seismic Design of Substations.

PART 2 – PRODUCTS

2.01 CONCRETE ANCHORS

A. Concrete anchors for equipment supports that are designed or specified by the Contractor or its Suppliers shall have a current and valid evaluation report from the International Code Council Evaluation Service (ICC-ES) and be suitable for seismic conditions and cracked concrete. Anchors susceptible to vibration environment shall not be used for anchorage of equipment that generates vibration, such as fans and generators.

PART 3 – EXECUTION

3.01 FIELD QUALITY CONTROL

A. The following special inspections related to the seismic qualification of equipment, and installation thereof, shall be performed by the Contractor’s independent testing agency:

1. Verify the test instrument calibration data and date.

2. Verify that the label and anchorage or mounting conforms to the certificate of compliance.

3. Perform inspection and testing of the anchorage of mechanical and electrical equipment, in accordance with the applicable ICC-ES or Evaluation Report or certification of compliance and requirement specified on the Contract for each type of anchor.

4. Verify that the seismically certified equipment is mounted and attached in the same manner and configuration that is was used to test and certify in lab.

5. Label seismically certified equipment. Label shall list certifying agency, performance criteria of equipment (i.e., the seismic capacity of equipment), report number or certificate of compliance used by agency to certify equipment, manufacturers name, and equipment model.

END OF SECTION 20 30 14

SECTION 20 40 13

IDENTIFICATION FOR FACILITY SERVICES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Pipe markers

B. Valve markers

C. Wet standpipe system

D. Equipment nameplates

E. Control nameplates

F. Valve list frame

G. Valve list

H. Valve list closure

I. Orifice plate tag

J. Duct identification and markers

1.02 RELATED SECTIONS

A. Section 20 70 26, Common Materials and Methods for Electrical Systems.

1.03 MEASUREMENT AND PAYMENT

A. General: Separate measurement or payment will not be made for the work required under this Section. All costs in connection with the Work specified herein will be considered to be included or incidental to the Work of this Contract.

1.04 REFERENCES

A. American National Standards Institute (ANSI):

1. ANSI/ASME A13.1 Scheme for the Identification of Piping Systems

B. State of California, Department of Transportation (Caltrans):

1. Standard Specifications, Section 85, Pavement Markers

2. Standard Specifications, Section 95, Epoxy

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Product Data: Submit manufacturer's product data of pipe markers, valve markers, equipment nameplates, control nameplates, orifice plate tag, and duct identification and markers.

C. Schedules: Submit valve schedule for each piping system, typewritten and reproduced on eight and a half by 11 inches bond paper for mounting. Tabulate valve number, piping system, system abbreviation (as shown on tag), location of valve (room or space), and variations for identification (if any). Mark valves which are intended for emergency shut-off and similar special uses with "flags" in the margin of the schedule. In addition to mounted copies, furnish extra copies as required for maintenance manuals as specified in Section 01 78 23, Operations and Maintenance Data.

D. Samples: Submit samples of each color, lettering style, and other graphic representation required for each identification material or system.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Pipe Markers:

1. Provide pipe markers of semi rigid plastic which are visibly accessible for maintenance operations (except piping in finished space). Include direction-of-flow arrows at each pipe marker. Pipe markers and flow arrows shall either be of the self-adhesive type or fastened to the pipe using epoxy-based adhesive. Adhesive used shall be approved by the Engineer.

2. Color code marker background with a clearly printed legend to identify the contents of the pipe. Conform colors, lettering size, and legend to ANSI A13.1.

3. Do not allow stainless steel piping to come into contact with pipe marker materials containing chlorides.

4. Identify potable waterlines so as to distinguish them from non-potable lines. Begin marking or identification on non-potable waterlines immediately down stream of back flow preventer.

B. Valve Markers: Brass tags one and a half inches in diameter. Letters shall be one fourth inch high and numbers shall be a half inch high. For supervised OS&Y and butterfly valve, letters shall be two inches by four inches, and numbers shall be one fourth inches. Marker fasteners shall be either four-ply 18 gage stainless steel wire, stainless steel "S" hooks, or stainless steel meter seals. Markers shall bear identifications as indicated.

C. Wet Standpipe System:

1. Requirements: Tunnel and Station wall signs shall be six inches by nine inches in size, opaque plastic back with anodized aluminum face. Letters shall be engraved, black, five eighths inch high, approximately three sixty-fourth inch wide Helvetica Compact style. The background of the sign shall be bright aluminum. The image shall be engraved below the anodized layer. Signs shall conform to color and finish of sample signs furnished by the Engineer.

2. Hose Valves: Signs, at each hose valve, shall have four lines of information. The first line shall be the track designation, such as C1 and C2; the second line shall be the mile post location such as MP XX.XX (closest mile post designation expressed in nearest hundredths of a mile); the third line shall be the primary fire department street address connection location; and the fourth line shall be secondary fire department street address location. Additional lines of information and other signs shall be as indicated.

3. Sectional Control Valves: The sign for each sectional control valve in a tunnel section shall have two lines of information. The first line shall be the track designation, such as C1 and C2; the second line shall be the milepost location, such as MP XX.XX; and the third line shall be the flasher control panel numbers as indicated.

4. Hose Valve Markers: Markers shall be blue, two-way reflective type, as specified in Caltrans Standard Specifications, Section 85.

5. Hose Valve Reflectors: Provide three-inch minimum metal-backed high reflective blue as approved by the Engineer. Reflectors shall be mounted on each side of galvanized steel wall brackets to be visible in either direction, as indicated.

6. Hose Valve Reflective Tape: Provide three fourths-inch wide high visibility white self adhesive tape.

D. FDC and PIV Signage: FDC: Identification escutcheon or plaques for standpipe system shall be cast brass and shall have the following designation; first line: “BART”, second line: either “WET STANDPIPE” or “AUTOSPKR” or “AUTOSPKR AND STANDPIPE”. PIV: Identification plaque shall be cast brass and shall have the following designation; first line: “BART”, second line: shall have a physical location description with respect to the BART system such as a station name or building name.

E. Equipment Nameplates: Aluminum, two inches by four inches, with a black enamel background and either etched or engraved lettering. Lettering shall be as indicated. Nameplates shall bear notations corresponding to the same notations on the framed wiring diagrams and operating instructions. Place warning signs on machines driven by electric motors which are controlled by fully automatic starters, in accordance with General Safety Orders Article 3281. Nameplates for electrical assets shall be in accordance with Specification Section 20 70 26, Common Materials and Methods for Electrical Systems.

F. Control Nameplates: Laminated colored plastic with white lettering. Each switch shall have its switch positions clearly indicated and identified. Nameplates shall be worded to identify the respective item and function.

G. Valve List Frame: Crafted wood or nonferrous metal with clear glass front.

H. Valve List: Provide on heavyweight white bond paper, either typed or printed and laminated between clear plastic.

I. Valve List Closure: Crafted of transparent plastic. Front and back plastic sheets, which form closure, shall be not thinner than 15 mils. Two holes shall be punched at top of plastic closure to allow a nickel-plated bead chain to be affixed thereto.

J. Orifice Plate Tag: Aluminum tag secured with not less than 18 gage stainless steel wire to the pipe extension. Tag shall identify make, model, bore diameter, and serial number of the portable meter connected to the device.

K. Duct Identification and Markers: Provide duct identification of all ducts, such as “warm air” and “return air”, and air flow directional arrows. Provide such identification at ten-foot centers along the duct. Also, identify all dampers by function. Duct identification markers and flow arrows shall be flexible plastic tape, permanent self-adhesive type or fastened with an epoxy adhesive.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Pipe Markers:

1. Install adjacent to each valve and fitting, except on plumbing fixtures and equipment; at each branch and riser take-off; at each pipe passage through wall, floor and ceiling construction; at each pipe passage to underground; and on ten foot centers on horizontal pipe runs. Install markers on exterior of insulation for insulated piping.

2. Identify potable water lines to distinguish them from non-potable lines. Begin markings or identification on non-potable water lines immediately downstream of backflow preventers.

B. Valve Markers: Fasten to valve body in location where markers can be easily read.

C. Wet Standpipe System:

1. Sectional control valve and hose valve signs shall be mounted to tunnel or station wall. Hose valve signs shall be mounted to the side of the hose valve. Sectional control valve signs shall be mounted below the valve, four feet six inches above walkway to bottom of sign. The signs shall be firmly attached to the tunnel or station wall using adhesive conforming to Caltrans Standard Specifications, Section 95-2.04, Rapid Set Epoxy Adhesive for Pavement Markers.

2. Reflectors specified in Article 2.01.C.5 shall be mounted on new brackets fastened to the tunnel wall directly across from each hose valve, as indicated. The reflector mount shall be located one inch clear below the bottom of the nearest milepost sign and positioned so as not to obstruct the train operator's vision of the sign.

3. Reflective tape specified in Article 2.01.C.6 shall be applied to the sides of the hose valve riser pipe with four parallel vertical strips equally spaced about a semicircle of the pipe nearest to the trackway, beginning six feet above the walkway and ending at the threaded elbow.

D. Valve List Frame: Mount on a wall in the mechanical room, where it can be easily read. One valve list shall be mounted in each frame. Mount with tamper-proof, corrosion-resistant fasteners.

E. Equipment Nameplates: Mount with tamper-proof, corrosion-resistant fasteners.

F. Control Nameplates: Mount with tamper-proof, corrosion-resistant fasteners.

G. Duct Identification and Markers: Install duct identification and markers on all ducts, where most visible, and on the exterior side of insulated ductwork. Install in accordance with the identification tape manufacturer's installation instructions and recommendations for the conditions.

END OF SECTION 20 40 13

SECTION 20 50 13

RACEWAYS FOR FACILITY SERVICES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Conduit.

B. Conduit hangers.

C. Inserts.

D. Surface mounted metal raceways and fittings.

E. Outlet boxes; junction and pull boxes.

F. Metallic cable trays.

G. Fiberglass cable trays.

H. Underfloor duct system.

I. Reinforced thermosetting resin conduit (RTRC).

1.02 RELATED SECTIONS

A. Section 07 84 00, Firestopping

B. Section 20 50 16, Underground Ductwork and Structures for Facility Services

C. Section 20 70 26, Common Materials and Methods for Electrical Systems

D. Section 26 05 24, Low Voltage Wires and Cables

E. Section 26 05 26, Grounding and Bonding for Electrical Systems

1.03 MEASUREMENT AND PAYMENT

A. Separate measurement and payment will not be made for the Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the Bid Schedule of the Bid Form, or incidental to the Work of the Contract.

1.04 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO)

B. American National Standards Institute (ANSI):

1. ANSI C80.6	American National Standards for Electrical Intermediate Metal Conduit (IMC)
2. ANSI/ ASME B1.20.1	Standard for Pipe Threads General Purpose (Inch)

C. American Petroleum Institute (API):

1. API 15LR	Specification For Low Pressure Fiberglass Line Pipe and Fittings

D. American Society for Testing and Materials (ASTM):

1. ASTM A123/ A123M	Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
2. ASTM A153/ A153M	Standard Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware
3. ASTM B117	Standard Practice for Operating Salt Spray (Fog) Apparatus
4. ASTM C97	Standard Test Methods for Absorption and Bulk Specific Gravity of Dimension Stone
5. ASTM C99	Standard Test Method for Modulus of Rupture of Dimension Stone
6. ASTM C170	Standard Test Method for Compressive Strength of Dimension Stone
7. ASTM C307	Standard Test Method for Tensile Strength of Chemical-Resistant Mortar, Grouts, and Monolithic Surfacings
8. ASTM C666/ 666M	Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing
9. ASTM D149	Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
10. ASTM D257	Standard Test Methods for DC Resistance or Conductance of Insulating Materials
11. ASTM D372	Standard Specification for Flexible Treated Sleeving Used for Electrical Insulation
12. ASTM D543	Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents
13. ASTM D570	Standard Test Method for Water Absorption of Plastics

14. ASTM D638 Standard Test Method for Tensile Properties of Plastics

15. ASTM D695 Standard Test Method for Compressive Properties of Rigid Plastics

16. ASTM D696 Standard Test Method For Coefficient of Linear Thermal Expansion of Plastics Between -30°C and 30°C with a Vitreous Silica Dilatometer

17. ASTM D790 Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

18. ASTM D792 Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement

19. ASTM D2105 Standard Test Method for Longitudinal Tensile Properties of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Tube

20. ASTM D2240 Standard Test Method for Rubber Property-Durometer Hardness

21. ASTM D2303 Standard Test Methods for Liquid-Contaminant, Inclined-Plane Tracking and Erosion of Insulating Materials

22. ASTM D2583 Standard Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor

23. ASTM E84 Standard Test Method for Surface Burning Characteristics of Building Materials

24. ASTM E831 Standard Test Method for Linear Thermal Expansion of Solid Materials by Thermomechanical Analysis

25. ASTM G154 Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials

E. International Organization for Standardization:

1. ISO 1461 Hot Dip Galvanized Coatings on Fabricated Iron and Steel Articles – Specifications and Test Methods

F. National Electrical Manufacturers Association (NEMA):

1. NEMA RN 1 Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit

2. NEMA TC 2 Electrical Polyvinyl Chloride (PVC) Conduit

3. NEMA TC 3 Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing

4. NEMA TC 14 Standard for Reinforced Thermosetting Resin Conduit (RTRC) and Fittings
5. NEMA VE 1 Metal Cable Tray Systems
6. NEMA VE 2 Cable Tray Installation Guidelines

G. National Fire Protection Association (NFPA):

1. NFPA 70 National Electrical Code (NEC)
2. NFPA 130 Standard for Fixed Guideway Transit and Passenger Rail Systems

H. Underwriters Laboratories Inc. (UL):

1. UL 5 UL Standard for Safety Surface Metal Raceways and Fittings
2. UL 6 UL Standard for Safety Electrical Rigid Metal Conduit-Steel
3. UL 50 UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations
4. UL 94 Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
5. UL 514B UL Standard for Safety Conduit, Tubing, and Cable Fittings
6. UL 568 UL Standard for Safety Nonmetallic Cable Tray Systems
7. UL 651 UL Standard for Safety Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fitting
8. UL 797 UL Standard for Safety Electrical Metallic Tubing-Steel
9. UL 1242 Standard for Electrical Intermediate Metal Conduit-Steel
10. UL 2196 Standard for Fire Test for Circuit Integrity of Fire-Resistive Power, Instrumentation, Control, and Data Cables
11. UL 2515 UL Standard for Safety Aboveground Reinforced Thermosetting Resin Conduit (RTRC) and Fittings

I. Precast/Prestressed Concrete Institute (PCI):

1. MNL-128 Recommended Practice for Glass Fiber Reinforced Concrete Panels

1.05 REGULATORY REQUIREMENTS

A. California Code of Regulations (CCR):

1. Title 24, Part 2 California Building Code

2. Title 24, Part 3 California Electrical Code

1.06 SUBMITTALS

A. General: Refer to Contract Specifications Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data and Samples, for submittal requirements and procedures.

B. List of Materials: At least 30 days before beginning the work of this Section, submit a list of materials and equipment proposed for use together with applicable standards. Give name of manufacturer, brand name, and catalog number of each item. Submit the list complete at one time, with items arranged and identified in numerical sequence by Specification Section and Paragraph number. For each material used, provide table matrix showing the specification requirement and the product data showing all specifications are met.

C. Compliance with Applicable Standards:

1. Where equipment or materials are specified to conform to the standards of organizations such as ANSI, ASTM, NEMA, and UL, submit evidence of such conformance for review and record purposes. The label or listing of the specified agency is acceptable evidence.

2. Instead of the label or listing, the Contractor may submit a written certificate from an approved, nationally recognized testing organization, adequately equipped and competent to perform such services, stating that the items have been tested and that the units conform to the specified standard.

3. Submit evidence of compliance with the seismic safety requirements of the California Building Code.

4. Equipment design and layout shall comply with the NFPA codes.

5. Submit raceway and conduit support and equipment mounting calculations.

D. Factory Test and Inspection Certification:

1. Except as otherwise specified herein, where factory tests and inspections for materials and equipment for which tests and inspections specified in referenced documents are waived, submit certified copies of reports for tests performed on previously manufactured identical materials or equipment within the previous 12 months.

2. Test reports shall include signed statements from the manufacturer certifying that the previously tested material or equipment is physically, mechanically, and electrically identical to that proposed for the project. Include wiring and control diagrams.

E. Shop Drawings:

1. Submit Shop Drawings for review showing the exact location and arrangement of conduits stubbed into future equipment, cross sections of ductbank with conduit sizes, cabinet, pull boxes and assigned spaces, conduit sleeves for future exposed conduits, and fabricated work being furnished and installed under these Specifications. Submit such drawings before rough-in work, fabrication, and within ample time to prevent delay in the Work.

2. Submit detailed drawings of reinforced cast-in-place and pre-cast concrete cable trenches, wireways, covers, divider partitions, support structures, anchors, and related metal work. Include installation and abutting joint details and instructions. Include transitions and connections at splice and pull boxes, wireways, cable trenches, and other related elements.

3. Submit nameplate, marking, and labeling.

4. Contract Drawings are diagrammatic and shall be evaluated based on actual field conditions to prepare detailed installation Shop Drawing submittals. Contractor shall submit detailed scaled Shop Drawings for all fabricated work being furnished and installed under these Specifications. Shop Drawings are to be submitted prior to rough-in work or fabrication and within ample time to prevent delays in the Work. Shop Drawing shall provide exact location and arrangement of installed materials including required offsets and clearances for the following raceway elements as a minimum:

    a. Exposed conduit and cable tray including sizes, structural supports, connections to pull boxes and cabinets, expansion fitting locations, cable tray dividers, grounding connections, core drill locations, and conduit sleeves including for future exposed conduits.

    b. Conduit ductbank including rebar arrangement, pull box and equipment foundation interfaces and transitions to exposed raceway or cable trough in accordance with Contract Specification Section 20 50 16.

    c. Cable trough system including offset distances and clearances from tracks, ties, switches, and other wayside equipment, showing a minimum 1 ft edge of tie to edge of trough clearance unless otherwise indicated. Details of bends and trough to ductbank transitions to the proposed cable trough system shall be included. Manufactured trough bends and transitions shall be submitted.

F. Field Test Reports: Submit certified field test reports of field tests, verifying electrical continuity of the raceway systems and grounding in accordance with Specifications requirements and applicable NFPA 70 Code sections.

G. Calculations: Submit calculations to demonstrate that the cable trough design meets the required load bearing capacity, and minimum and maximum dimensions shown on the standard details, certified by a professional engineer, registered in the state of California. Submit certifications and structural calculations to the Engineer.

H. Test Data: Submit test data for RTRC assemblies as outlined in these specifications from an authorized certified testing lab.

I. Samples: Submit one sample for each type as indicated.

1.07 RTRC QUALITY ASSURANCE

1. Manufacturer provided training shall be provided and documented for supervising installation personnel prior to installation work being performed.

2. Pre-qualification split anchor rings installation and joint pullout testing requirements:

   a. Contractor shall demonstrate proficiency in installation of the material by providing test samples and having the samples tested at an authorized certified laboratory as described in this section. Qualified installers shall follow the manufacturer's recommended installation procedures before performing any split anchor rings installation and joint pullout testing. Submit a RTRC conduit prequalification report that includes:

      1) Copy of the manufacturer's product literature of complete data on the split anchor rings materials, installation and joint pullout testing procedures.

      2) Installation of the split anchor rings shall include the use of a guide to ensure even alignment of the ring halves and the use of zip ties to secure rings while epoxy cures.

      3) Names of the operators who will be performing the field installation and testing.

      4) Description of the positions, locations, tools and equipment, and procedures that will be used in the work.

      5) Certified test results from the authorized laboratory for the prequalified test samples.

      6) Certifications from the QC manager for operator and procedure pre-qualification.

      7) Manufacturer's QC process control manual.

   b. Installation and testing procedures on split anchor rings and joint pullout test samples of the type shall be used in the work. Splice test samples and testing shall comply with the QC testing requirements specified.

   c. Engineer may witness installers and procedure qualification tests for split anchor rings and joint pullout testing assemblies.

   d. Submit an inspection request form to the Engineer at least 10 working days before performing any installer or procedure qualification tests.

e. Perform tests per ASTM D2105 for joint pullout and comparable ASTM test method for split anchor ring. Submit test method and procedure for review. Use testing equipment that is in good condition and properly calibrated. Notify the Engineer in advance so that the Engineer may witness the test procedures.

   1) A minimum of nine specimens of each assembly is required for each size and class to be supplied.

   2) Each test cycle shall involve a complete test of nine specimens.

   3) Nine specimens of a test cycle shall be tested in one batch by the same authorized laboratory.

   4) Specimens in the same test cycle shall be prepared in one batch by the same installers.

   5) Contractor may prepare extra specimens as spare for the same test cycle in the case of rejection of specimen due to obvious flaw during the test.

f. The set of specimen test results shall comply with the following criteria. Otherwise another test cycle shall be performed.

   1) Eliminate the maximum and minimum failure loads from nine specimen test results.

   2) The minimum failure load of the remaining seven specimen test results shall meet or exceed the strengths listed in Article 2.01G(2).4 for phenolic conduit or 2.01G(3).5 for epoxy conduit.

   3) Unless the minimum failure load of the remaining 7 specimen test results is 2 times more than the required strengths in Article 1.07.2(f).2, the standard deviation of the remaining 7 specimen test results shall be no more than 15 percent of the average of the remaining 7 specimen test results.

g. Before transporting split anchor ring and joint pullout test samples to an authorized laboratory:

   1) Securely bundle and package the test samples for each in a way that preserves their condition during transportation.

   2) Identify each test sample by location, lot number, and Contract number using weatherproof markings.

   3) Attached a completed sample identification card to each bundle.

h. At least 10 working days before performing any testing at the authorized laboratory, notify the Engineer of:

   1) Date of the testing.

   2) Location of the authorized laboratory where the tests will be conducted.

   3) Number of lots to be tested.

i. If a specimen test is rejected due to obvious flaw, replace for re-testing.

j. If in the same test cycle more than 3 specimens are rejected due to obvious flaw, notify the Engineer and prepare a test rejection mitigation report describing:

1) Cause of the failure

2) Method used to identify the cause of failure

3) Provisions for preventing similar failures in future tests

4) Procedure for replacing

1.08 RTRC DELIVERY, STORAGE, AND HANDLING

A. Conduits shall be shipped in self-supporting crates designed to be unloaded by forklift. Crates shall not be dropped from the truck trailer flat-beds. Each crate shall be legibly marked with the following information:

1. Manufacturer's identification

2. Product description

3. Purchase order number

4. Stock number

5. Date of manufacture

B. Conduit crates shall be stored on a level surface in an environment free from excessive dirt, dust, or other airborne contaminants. The vertical support of the wooden frames should line up (below) so the load will be transferred to the wood frames rather than the conduit. The height of stacked conduit shall be limited to 12 feet.

C. Packing system for conduits and fittings shall be provided with adequate amount of interval support spacing during shipping and subsequent storage by the District to mitigate any deflection or deformity. Deformed or bowing conduits will be rejected.

D. Elbows and accessories, when stored outdoors, shall be under cover to protect items in cartons from the outdoor elements.

E. Epoxy adhesives shall have a shelf life at least 9 months printed on the can at the time of receipt the products, and shall be stored at 68 degrees Fahrenheit to 77 degrees Fahrenheit except when in use on the Jobsite. Adhesives shall not be stored in freezing areas.

PART 2 – PRODUCTS

2.01 CONDUIT

A. Galvanized Rigid Steel (GRS) Conduit and Accessories:

1. Provide conduit, couplings, elbows, bends, sealing fittings, and nipples conforming to NEMA RN 1 and UL 6, with each length bearing manufacturer's stamp and UL label.

2. Provide only GRS conduit and accessories for the following applications and in accordance with NFPA 130:

   a. Emergency lighting system

   b. Fire alarm system

   c. Train control system

   d. Life safety systems

   e. Elevator/escalator system

3. Provide only GRS conduit and accessories for all installations compliant with NFPA 130 in station under platform chase, subway, and subway passenger stations including ventilation fans, lighting and sump pumps, except when conduits are embedded in concrete.

4. Fittings and Accessories:

   a. Provide separable watertight hub fittings with a gasket, separate nylon insulated throat, and a casehardened locknut.

   b. Provide bushings of nylon-insulated metallic and grounding type.

   c. Provide conduit straps, clamps, and clamp backs made of galvanized malleable iron.

   d. Conduit, connections and couplings shall be threaded.

   e. Rigid steel conduit shall be a minimum of 3/4-inch diameter at exposed portions and 1-inch diameter at embedded portions.

   f. Access fittings shall be gasketed cast covers.

   g. Set-screw type and compression type are not acceptable.

5. Rigid steel conduit shall be hot-dipped galvanized after fabrication.

B. Electrical Metallic Tubing: Provide electrical metallic tubing (EMT) conforming to UL 797. Provide raintight galvanized steel compression connectors and couplings with insulated throat.

C. Polyvinyl Chloride (PVC) Coated Conduit:

1. Provide PVC-coated conduit conforming to NEMA RN 1, Coating Type A-40.

2. Thread protectors installed on both ends of conduit for shipment and handling, with couplings packaged separately.

3. Provide PVC-coated metallic conduit and adapter for the transition of a PVC conduit embedded in slab and the aboveground metallic conduit. Ensure that the aboveground PVC-coated metallic conduit is two feet minimum above ground.

4. Fittings shall be watertight.

D. Liquid-tight Flexible Metallic Conduit and Fittings:

1. Provide conduit consisting of a core of flexible galvanized steel with an extruded liquid-tight plastic or neoprene jacket overall. Jacket shall be moisture- and oil-proof, capable of conforming to the minimum radius bends of flexible conduit without cracking.

2. Provide conduits with a continuous copper bonding conductor spiral wound between the convolutions, as required by California Electrical Code, and in accordance with Section 26 05 26, Grounding and Bonding for Electrical Systems.

3. Conduit and fittings shall be of self-extinguishing type with low halogen containing material.

4. Provide fittings conforming to UL 514B, zinc-coated.

E. PVC Electrical Conduit and Fittings:

1. Provide heavy wall, high impact strength, rigid PVC conforming to the requirements of EPC-40-PVC conduit of NEMA TC 2 and fittings for EPC-40-PVC conduit of NEMA TC 3.

2. Provide Schedule 80 conduit for underground and trench installation with vehicle traffic.

3. PVC shall not be installed exposed.

4. Conduit and fittings shall be UL 651 listed and shall conform with Article 352 of the California Electrical Code for underground and exposed use.

5. Conduit and fittings shall be flammability rated as self-extinguishing, and shall have the following minimum properties:

   a. Tensile strength, ASTM D638 at 78 degrees Celsius: 6,000 psi.

   b. Flexural strength, ASTM D790: 11,000 psi.

   c. Compressive strength, ASTM D695: 8,500 psi.

d. Hardness (Durometer D), ASTM D2240: 77.

e. Water absorption, percent maximum in 24 hours at 72 degrees Celsius, ASTM D570: 0.03.

f. Dielectric strength, ASTM D149: 1.1 kV/mil.

g. Thermal conductivity: 1.3 Btu/sq. ft./deg. F/in.

F. Intermediate Metal Conduit (“IMC”) and Accessories:

1. Provide conduit, couplings, elbows, bends, sealing fittings, and nipples conforming to NEMA RN 1 and UL 6, with each length bearing manufacturer’s stamp and UL label.

2. Conduit shall comply with UL1242, ANSI C80.6, and ANSI B1.20.1.

3. Fittings and Accessories:

a. Provide separable watertight hub fittings with a gasket, separate nylon insulated throat, and a casehardened locknut.

b. Provide bushings of nylon-insulated metallic and grounding type.

c. Provide conduit straps, clamps, and clamp backs made of galvanized malleable iron.

d. Intermediate metal conduit shall be a minimum of 3/4-inch diameter at exposed portions and 1-inch diameter at embedded portions.

e. Conduit, connections and couplings shall be threaded.

G. Metal Clad Cable System:

1. Metal clad cable system shall be used for tunnel lighting when conduit and cable are exposed to the track.

2. Representative components comprising a cable system shall be tested as a system that includes but limited to cable boxes, terminations, and connectors and shall comply to NFPA 130.

3. Components shall be tested and certified by applicable UL, NEMA, and ASTM standards.

4. All required listings shall encompass the cable type, construction, and conductor size range procured.

5. Separate ground wire shall be provided.

6. Provide labeling and marking of source, circuit numbers and destination.

H. Reinforced Thermosetting Resin Conduit (RTRC):

1. RTRC shall be used for traction power applications and shall comply with NFPA 130. RTRC phenolic low smoke zero halogen conduits shall be used for tunnel and enclosed spaces. RTRC epoxy conduit shall be used for all other locations.

2. RTRC conduit, fittings, and accessories shall comply with the following requirements:

   a. Contractor shall perform pre-qualification assembly testing as described in Article 3.02F herein for each RTRC types (epoxy, phenolic), wall (HW, XW) and sizes (2 inch through 6 inch) as indicated.

   b. Conduit, fitting, and accessories shall be UL listed and conform to NFPA 130, NFPA 70, and NEC 2017 Article 355.

   c. Conduit shall be provided with yellow insertion line at spigot end to confirm correct installation.

   d. Conduit shall be supplied with spigot ends factory sanded. Fittings and accessories to be part of the conduit system shall be supplied factory sanded.

   e. Conduit fittings shall be manufactured from the same process, methods, and chemicals of the materials as the conduits and have a socket depth and an inside bell design consistent with the conduit.

   f. At every conduit support location, provide 1/8 inch thick by 2 inch wide self-adhesive cushion material around entire circumference of conduit. The cushion material shall consist of high-grade neoprene with Type A durometer hardness of 50.

I. Phenolic Reinforced Thermosetting Resin Conduit (RTRC) Fittings and Accessories:

1. Provide a rigid non-metallic low smoke, zero halogen, phenolic RTRC conduit, couplings, expansion joints, elbows, bends, sealing fittings, split anchors rings and nipples for locations as indicated on the Contract Drawings. Conduit shall be fire resistant and low flame spread.

2. Conduit shall utilize straight socket joint and an epoxy adhesive by manufacturer’s recommendations.

3. Conduit, fitting, and accessories shall be UL listed, to the UL 2515.

4. The Contractor shall submit test certification or data and structure calculations to the Engineer for approval indicating that the proposed product can meet or exceed the following test strengths as outlined in the Table 1:

Table 1: Phenolic Conduit Test Strength

Phenolic XW Conduit		
	Split Anchor Ring	Joint Pullout
6 inch Conduit	6000 lbs	4000 lbs
4 inch Conduit	4000 lbs	4000 lbs
2 inch to 3 inch Conduit	4000 lbs	4000 lbs
Phenolic HW Conduit		
6 inch Conduit	4000 lbs	1850 lbs
4 inch Conduit	1300 lbs	1400 lbs

5. Acceptable RTRC phenolic conduit properties are outlined in the following Table 2:

Table 2: Phenolic Conduit Material Property

Material Property	**Phenolic RTRC XW**	**Testing Method**
Dielectric Strength	150 to 500 volts/mil	ASTM D149
Water Absorption	< 1.5 percent	ASTM D570
Modulus of Elasticty	$1.2x10^6$ to $1.3x10^6$ psi	ASTM D2105
Coefficient of Thermal Expansion	$0.51x10^{-5}$ in/in/°F	ASTM D696
Specific Gravity	1.70 to 1.75 g/cm3	ASTM D792
Barcol Hardness	48 to 72	ASTM D2583
Glass Content	65 to 75 percent	API 15LR

J. Epoxy Reinforced Thermosetting Resin Conduit (RTRC) Fitting and Accessories:

1. Provide rigid non-metallic low smoke, epoxy RTRC conduits, couplings, expansion joints, elbows, bends, sealing fittings, split anchor rings, and nipples for locations as indicated on the Contract Drawings.

2. Conduit shall be UV stable (sunlight resistance) per UL 2515.

3. Conduit, fitting, and accessory shall be UL listed to UL 2515.

4. Conduit shall utilize straight socket joints with epoxy adhesive per manufacturer's recommendations.

5. The Contractor shall meet or exceed the following test strengths as outlined in the Table 3:

Table 3: Epoxy Conduit Test Strength

Epoxy XW Conduit		
	Split Anchor Ring	Joint Pullout
2 inch to 3 inch Conduit	5500 lbs	10000 lbs
Epoxy HW Conduit		
	Split Anchor Ring	Joint Pullout
6 inch Conduit	9000 lbs	11500 lbs
4 inch Conduit	7000 lbs	4500 lbs

6. Acceptable RTRC Conduit properties are outlined in the following Table 4:

Table 4: Epoxy Conduit Material Property

Material Property	Epoxy RTRC		Testing Method
	Extra Heavy Wall (XW)	Heavy Wall (HW)	
Dielectric Strength	500 volts/mil	500 volts/mil	ASTM D149
Water Absorption	< 1.0 percent	< 1.0 percent	ASTM D570
Modulus of Elasticity	1.3 to 1.4x10^6 psi	1.3 to 1.4x10^6 psi	ASTM D2105
Coefficient of Thermal Expansion	1.2x10^{-5} to 1.37x10^{-5} in/in/°F	1.2x10^{-5} in/in/°F	ASTM D696
Specific Gravity	1.90 to 1.94 g/cm3	1.90 g/cm3	ASTM D792
Barcol Hardness	52 to 56	52 to 56	ASTM D2583
Glass Content	65 to 71 percent	65 to 75 percent	API 15LR

K. RTRC Conduit Wall Thickness:

1. Reference conduit wall thickness are outlined in the following Table 5:

Table 5: Conduit Wall Thickness

	SIZE	XW (Phenolic)	XW (Epoxy)	HW (Epoxy)
RTRC	6 inch	0.25 inch (6.4mm)	0.25 inch (6.4mm)	0.110 inch-0.115 inch (2.8 to 2.9mm)
	4 inch	0.25 inch (6.4mm)	0.25 inch (6.4mm)	0.095 inch – 0.096 inch (2.4mm)
	3 inch	0.25 inch (6.4mm)	0.25 inch (6.4mm)	N/A
	2 inch	0.25 inch (6.4mm)	0.25 inch (6.4mm)	N/A

L. RTRC Marking:

1. Conduit and elbows shall be durably and legibly marked in accordance with UL 2515, Section 6. The marking intervals shall not exceed 5 feet. Elbows shall have at least one of each marking. The following information shall be printed on the conduit, in lettering not less than 1 inch high:

   a. Wall thickness (inches)

   b. UL 2515 listing label

   c. Manufacturer’s name

   d. Date of manufacturing

   e. Angle and radius marked on elbows

2. If any of the preceding information cannot be printed on the conduit, the District shall be consulted prior to approval.

Conduit

M. Expansion Fittings:

1. Fabricate expansion fittings from material similar to the type of conduit with which they are to be used.

2. Include a factory installed packing ring, designed to prevent the entrance of moisture, and a pressure ring.

3. Include a grounding ring or a grounding conductor for metallic expansion couplings.

4. Fittings shall maintain a constant inside diameter in every position and shall provide a smooth wireway for protection of wire insulation.

2.02 CONDUIT HANGERS

A. Provide trapeze type multiple conduit hangers and supports as indicated or required.

B. Fabricate hangers from two or more steel hanger rods, a steel horizontal member, U-bolts, clamps, and other attachments as necessary for securing hanger rods, and conduits.

C. Provide galvanized hanger rods not smaller than three eighths-inch diameter, threaded either full length or for a sufficient distance at each end to permit at least one and a half inches of adjustment.

D. Provide horizontal member meeting the following requirements:

1. Standard structural steel shapes such as angles or channels, one and a half by one and a half inches or one and five eighths by one and five eighths inches, 12 gage, cold-formed, lipped channel, and designed to accept special spring-held hardened steel nuts for securing hanger rods and other attachments. Nuts and clamps shall be compatible with the channel.

2. Two or more channels may be welded together to form horizontal members of greater strength.

3. All members shall be hot-dip galvanized after fabrication in accordance with ASTM A123/A123M or ASTM A153/A153M, as applicable.

E. Design of conduit hangers shall meet the following requirements:

1. Conduit hangers shall be capable of supporting a load equal to the sum of the weights of the conduits and wires, the weight of the hanger itself, plus 200 pounds.

2. The stress at the root of the thread of the hanger rods shall be not more than 9,475 psi at design load.

3. Size the horizontal member such that the maximum stress will be not more than 12,650 psi at design load.

4. Conduit support system shall be designed to withstand the seismic loads specified in the California Building Code and the California Electrical Code.

F. RTRC Beam Clamps and Accessories:

1. Provide beam clamps and accessories as indicated on the Contract Drawings. Beam clamps shall be BY1G12 by LNA or equal. Beam clamp packing pieces shall be BF3G12 by LNA or equal. Beam clamps shall be torqued to 66 ft-lbs.

2. Beam clamps and accessories shall be hot-dip galvanized after fabrication in accordance with ISO 1461 or equivalent, as applicable.

3. If an equivalent product is proposed, the Contractor shall meet or exceed the following allowable design strengths:

   a. Tension: 2423 lbs. per bolt.

   b. Friction: 1165 lbs. per two bolts for painted steel and 3105 lbs. per two bolts for galvanized steel.

G. RTRC Bolts and Fasteners:

1. Steel to Steel Fasteners

   a. Fasteners including comparable nuts and washers shall be hot-dip galvanized steel or stainless steel.

   b. Fasteners with other types of materials or finishes may be submitted to Engineer for review and approval.

2. Concrete Anchor Bolts

   a. Cast-in-place Anchors:

      1) Refer to Contract Specification Section 03 15 23.

   b. Drilled in Anchors:

      1) Refer to Contract Specification Section 03 15 23.

3. Other types of anchors or finishes may be submitted to Engineer for review and approval.

2.03 INSERTS

A. Channel Inserts:

1. Fabricate from a minimum 12 gauge steel channel having an overall size of one and five eighths by one and five eighths inches with continuous seven eighths-inch wide slot, in lengths as indicated. Galvanize after fabrication.

2. Inserts for embedding in concrete shall conform to the following requirements:

   a. Fabricate from channels having a solid base.

   b. Weld concrete anchors to the channel during fabrication and before coating.

   c. Clean and galvanize after fabrication.

   d. Provide assemblies with a minimum pull-out load rating of 2,000 pounds per linear foot uniformly distributed, with a safety factor of three.

   e. Furnish channel inserts for installation embedded in concrete with the channel interior completely filled with styrofoam to prevent seepage of concrete into the channel during installation.

3. Inserts for surface mounting shall conform to the following requirements:

   a. Fabricate from channel having three eighths-inch by three-inch slots on four-inch centers in the base.

   b. Galvanize, in accordance with ASTM A123/A123M or ASTM A153/A153M, as applicable, inserts for surface mounting on concrete surfaces and for installation in damp or wet areas.

B. Spot Inserts for Embedding in Concrete:

1. Steel, galvanized after fabrication, in accordance with ASTM A153/A153M.

2. Design for a maximum loading of 800 pounds with a safety factor of three.

3. Knockout openings to accommodate either square or rectangular nuts.

2.04 SURFACE-MOUNTED METAL RACEWAYS AND FITTINGS

A. Provide surface-mounted metal raceways and fittings, where indicated, conforming to UL 5 and California Electrical Code.

2.05 OUTLET BOXES; JUNCTION AND PULL BOXES

A. Provide outlet boxes, junction boxes, and pull boxes conforming to California Electrical Code, Article 314.

B. Outlet boxes, junction boxes, and pull boxes shall be accessible.

C. Electrical boxes shall conform to UL 50.

D. Boxes labelling shall be as indicated in the Contract Drawings. Boxes shall be labeled with its unique identifier, source, and circuit numbers.

E. Provide electrical boxes of the material, finish, type, and size indicated and as required for the location, kind of service, number of wires, and function. Boxes shall have mounting holes for No.10-24 machine screws.

F. Provide boxes complete with accessible covers designed for quick removal and suitable for the purpose for which they will be used, except that boxes in which, or on which, no devices or fixtures are to be installed shall be equipped with flat or raised blank covers as required. Ceiling fixture outlet boxes shall be equipped with 3/8-inch boltless fixture studs.

G. Boxes below 100 cubic inches in size shall be cast metal. Boxes over 100 cubic inches in size shall conform to the requirements for cabinets, except boxes in interface pull boxes shall be cast metal boxes with gasketed cast metal covers. Boxes for surface mounted wiring devices shall be NEMA Type FD.

H. Covers for floor-mounted boxes shall be steel checker plate and of same thickness as boxes and shall be secured in position by means of No.10-24 stainless steel machine screws. Arrange covers to be readily and conveniently removed.

I. Junction boxes shall be zinc-coated (galvanized) inside and outside. Outlet boxes used as junction boxes shall not be smaller than 4-inches square by 1-1/2-inches deep. Provide such boxes with flat blank covers.

J. Outlet boxes for exposed installation shall be cast metal, not smaller than 4-inches square by 2-1/8-inches deep. For embedded or concealed installation, use cast metal boxes approved for intended purpose. Outlet boxes exposed to the public shall have tamper proof screw covers.

K. Concealed, flush or surface-mounted switch boxes shall be not less than 4-inches square by 1-1/2-inches deep for two devices, unless otherwise indicated. Provide covers with openings of proper size and shape. Provide special boxes as required to suit the kind of service and location requirements.

L. Provide brackets, supports, hangers, fittings, bonding jumpers, and other installation accessories as required.

M. Provide neoprene gaskets 1/8-inch thick for boxes subjected to weather. Provide fire resistant gaskets for pull boxes installed at the conduits for emergency equipment, feeder cables, and fire protection circuits.

N. Provide each box with a grounding terminal as follows:

1. Provide grounding terminal of either a green-colored washer-in-head machine screw not smaller than No. 10-32 in a drilled, tapped, and threaded hole in the back of the box, or a grounding bushing with green-colored machine screw terminal attached to one of the conduits.

2. Provide grounding terminals in motor connection boxes.

3. Install grounding jumpers as specified in Section 26 05 26, Grounding and Bonding for Electrical Systems.

O. All boxes for systems control and communications applications shall conform to NEMA Type 4 and shall be provided with NEMA Type 4 labels.

P. Pull boxes for ENT installation shall be no more than 100 feet apart.

Q. Pull boxes on sidewalks and planter areas shall be made of fiberglass and reinforced polymer concrete and UL listed. Pull box lids shall have a non-skid surface. Boxes shall have bolted down covers. Heavy-duty H20 loading Traffic Boxes with steel checker plate screw down covers shall be provided where pull boxes are used on roadways or parking lots.

R. Cover Labels: Pull box coves shall be engraved with the words labeling the owner “BART”, type of facility “ELECTRICAL” or “FIBER OPTICS”, “SOLAR PV” “EV #”, the voltage level “H.V.” or “480V”, or unless otherwise noted on the Contract Drawings. Letter size shall be as indicated on the Contract Drawings. Checked lids shall have flush mounted nameplates or the letters shall be welded. No surface mounted labels are allowed. All covers shall be permanently marked on the underside with the manufacturer’s name and the date of the manufacturer in this format: mm/yy.

S. Specific Requirements for Metal Clad Cable Systems Enclosures:

1. UL Listings:

   a. System: UL 2196 fire rated and NFPA 130 compliant.

   b. Enclosure: UL 50 and rated NEMA 4X.

   c. Terminations: UL 1773.

2. Other Enclosure Requirements:

   a. Enclosure shall be stainless steel and have a hinged cover.

   b. Enclosure shall have silicone gasket material.

3. Enclosure shall have internal cover and internal spacing meeting NEC.

2.06 METALLIC CABLE TRAYS

A. General: Provide metallic cable tray systems conforming to NEMA VE 1, except for modifications indicated. Cable tray system shall be designed to withstand the seismic load specified in the California Building Code and the California Electrical Code.

B. Cable Tray System Components:

1. Provide components of hot-dip galvanized steel in accordance with ASTM A123/A123M, or stainless steel Type 304 or Type 316, as indicated.

2. Install bonding jumpers at all cable tray connections. Bonding jumpers shall be sized to withstand maximum short circuit current.

C. Dimensions: Straight sections and fittings shall have inside clear width as indicated, measured between the rails. Width of tray shall be six inches minimum. Overall width shall not exceed inside width by more than two and a half inches. Loading depth of tray shall be three inches minimum. Inside nominal depth shall be five inches minimum. Overall tray depth shall be six inches.

D. Fabrication:

1. Provide straight sections and fittings consisting of stiffened channel rungs located between channel-shaped side rails having outward projecting flanges.

2. Rungs shall be positioned to provide a flat, cable support surface at least one and one eighth inches wide, excluding corner radii, and shall be 0.060 inch thick. MIG-weld rungs to side rails and clean welds. Tray rungs shall be spaced six inches on center.

3. Provide straight-section side rails having a top flange not to exceed one and a fourth inches wide and a minimum three eighths-inch vertical stiffening lip.

4. The radius of curved fittings shall be 24 inches minimum, unless otherwise approved by the Engineer.

5. Where indicated, provide solid bottom type straight sections and fittings consisting of two-sided rails with a solid corrugated bottom welded to the side rails. Provide solid flanged covers to match solid bottom tray construction.

E. Test Requirements:

1. The metallic cable tray system shall be capable of supporting a total cable load of 55 pounds per linear foot for cable tray of 30 inches wide or less and 88 pounds per linear foot for cable tray over 30 inches wide on a maximum span of eight feet including a static concentrated load of 200 pounds as specified below, with a safety factor of two based on the destructive load, regardless of the type of splice plates or type of span, when tested in accordance with load test procedure specified in NEMA VE 1, Section 4.

2. Straight sections and fittings shall not permanently deform under a 200 pound static concentrated load applied vertically along a four inch length for both of the following conditions:

   a. Load applied to center of one tray section having specified cable load and support spacing. Load shall be applied at midpoint between supports over a splice connection.

   b. Load applied to one rung of empty tray section having specified support spacing. Load shall be located at midpoint between side rails and supports.

F. Cable Tray Supports:

1. The cable tray system shall be supported at five-foot spans and shall be capable of carrying a working load of 100 pounds per linear foot, with a safety factor of 3.0 when loaded in accordance with NEMA VE 1, Section 3, and tested in accordance with NEMA VE 1, Section 4. All fittings, supports, and accessories shall be manufactured or fabricated in accordance with the cable tray manufacturer's recommendations.

2. Cable tray supports fabricated from minimum 12 gage steel channel, one and five eighths inches by one and five eighths inches, with a continuous seven eighths-inch wide slot, hot-dip galvanized after fabrication will be acceptable.

3. Provide assembled supports, fittings, brackets, and hardware to carry the loads as indicated with a factor of safety of three or greater.

4. Supports shall provide at least one and an eighth inch bearing length for each rail and shall have provision for tray hold-down clamps and fasteners.

5. Anchorages and fastenings to underside of roof or ceiling require approval of the Engineer before they may be used in the work. Anchorage and fastening to pre-stressed girders, beams, and slabs will not be permitted.

2.07 FIBERGLASS CABLE TRAYS

A. Where the cable tray system is indicated or required to be fiberglass-reinforced plastic (FRP), provide such FRP cable tray system conforming to NEMA, except for modifications indicated. Use metallic hardware, units and bolts, if required. Conform with all requirements of the herein specified metallic cable trays as applicable to plastic systems. Provide special grounding and bonding in accordance with Section 26 05 26, Grounding and Bonding for Electrical Systems, as required for plastic systems.

B. For Traction Power Applications:

1. Provide fiberglass-reinforced plastic (FRP) cable tray system where indicated confirming to UL 568 and special grounding and bonding in accordance with Section 26 05 26, Grounding and Bonding for Electrical Systems, as required for plastic system.

2. Fiberglass reinforced plastic (FRP) cable trays shall be low smoke, zero halogen type as indicated in the Contract Drawings. Tray shall be non-ventilated with solid bottom and top cover. Fittings, supports, and accessories shall be manufactured or fabricated in accordance with the cable tray manufacturer's recommendations. Cable tray shall be by Enduro Composites, B-Line or equal.

2.08 UNDERFLOOR DUCT SYSTEM

A. Provide underfloor duct system consisting of junction boxes, ducts, extension rings, hold-down straps, and accessory parts to form complete assemblies, made watertight with sealing compound. Fabricate primary components of the system of 14 gage steel, with an approved corrosion-resistant coating.

B. Provide junction boxes with openings on each of the four sides to receive two ducts, each one and a half inches high by six and a half inches wide; and having a round top cover of approximately 22 inches in diameter for access to cables. Fit junction boxes with interior partitions which isolate each duct and concurrently form a continuous raceway through the box in both directions.

C. Each raceway shall have a minimum inside area of eight and a half square inches for large duct or three and three tenths square inches for small duct. Close off unused junction box openings with blank panels. Fit boxes with four pad-and- screw assemblies for bolting boxes to the structure and for leveling and height adjustments.

D. Provide extension rings matching the junction boxes, if required, in a height which, along with heights of the junction box and cover, combine to bring the total height of the assembly to four and a half inches, the approximate thickness of the finish floor. The leveling and height adjustment screws in the junction box shall have a minimum upward adjustment of three eighths-inches and shall be used for final adjustment to bring the top of the cover plates level and flush with the top of the finish floor.

E. Provide junction box cover plates of stainless steel or brass and recess three fourths-inches minimum to hold a section of paver matching adjacent pavers in the station finish floor. Provide junction box cover plates not exposed to public view of flat stainless steel.

F. In addition to furnishing accessory parts to form a complete assembly, furnish core drills, hole saws, afterset inserts, and insert extensions as required for normal installation.

G. Junction boxes and cover plates shall be watertight.

2.09 POLYMER CONCRETE CABLE TROUGH

A. General Requirements:

1. Polymer concrete cable troughs shall be composed of fiberglass reinforced high density polymer concrete material.

2. Polymer concrete trough covers shall be composed of fiberglass reinforced high density polymer concrete material. The covers shall be manufactured using matched die molds to ensure consistency.

3. Where indicated by the Contract Drawings, cable troughs may consist of rigid dividers integrated into the body of the trough. The dividers shall be cast from the same polymer concrete material as the trough body and shall be incorporated into the trough mold design.

4. Cable troughs shall be designed to accommodate a 1-degree bend over two (2) joined sections and up to a 3-degree bend over five (5) sections that shall be sufficient to permit cable trough to parallel track curvature without modification.

    a. Where tighter bend radius is required, manufacturer may design and furnish elbow sections that are compatible with other trough materials supplied. The dimensions of these elbow sections shall be designed per Contract.

5. Cable troughs shall allow for trouble-free drilling with a hole saw for cable transition to conduits. A jab saw or keyhole saw shall be used for opening rounded or slotted holes through the sidewall or bottom of the cable trough for cable exits and entrances.

6. Mounting and fastening hardware shall be non-magnetic stainless steel type 304.

7. Cable trough covers shall incorporate a non-skid surface design to mitigate slipping hazard.

B. Material Requirements

1. Poly concrete material shall consist of calcareous and siliceous stone, glass fibers and thermoset polyester resin.

2. Raw materials used in the production of polymer concrete cable troughs shall be performance certified by the manufacturer of origin.

3. The polymer concrete shall meet the material requirements as outlined in the following Table 6:

Table 6: Material Property

Material Property	Testing Standard	Value
Compressive Strength	ASTM C170	Min: 21,000 psi
Flexural Strength	ASTM D790	Min: 19,000 psi
Flexural Modulus	ASTM D790	Min: 1,670,000 psi
Ultimate Shear Strength	ASTM D372	Min: 6,000 psi
Modulus of Rupture	ASTM C99	Min: 6,500 psi
Tensile Strength	ASTM C307	Min: 2,000 psi
UV Radiation Resistance	ASTM G154	No significant change
Chemical Resistance	ASTM D543	Acceptable
Coefficient of Thermal Expansion/Contraction	ASTM E831	11.95×10^{-6} °F
Water Absorption	ASTM D570	Max: 2 percent
Density		0.067 to 0.069 lbs/cu. in
Fire Resistance	ASTM E84	NFPA Class A Material
Flammability	UL 94	Passed UL 94 V-0
Freeze Thaw	ASTM C1026	No cracks or damage
Electrical Resistivity Test	ASTM D257	Insulating Material

Electrical Tracking Resistance	ASTM D2303	Min: 1200 Minutes
Salt Spray	ASTM B117	No Significant Change

C. Structural Requirements

1. Polymer concrete cable trough and cover assemblies shall be capable of withstanding AASTHO HS20-44-wheel loading.

2. Polymer concrete cable trough and cover assemblies shall be capable of withstanding a vertical design load of 20,800 pounds (16,000 lb. plus 30 percent impact factor) over a 10 inch by 20 inch by 1 inch steel plate backed with a 10 inch by 20 inch by 1/2 inch rubber pad.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install electrical raceway materials, equipment, and accessories in locations as indicated, rigid and secure, plumb and level, and in alignment with related and adjoining work to provide a complete and operable system. Do not weld electrical materials for attachment or support, except as otherwise specified in Section 26 05 26, Grounding and Bonding for Electrical Systems, for electrical continuity bonding and grounding.

B. Provide anchor bolts and anchorage items as required, and field check to ensure proper alignment and location. Provide templates, layout drawings, and supervision at the jobsite to ensure correct placing of anchorage items in concrete. Check embedded items for correctness of location and detail before concrete is placed.

C. Install supporting members, fastenings, framing, hangers, bracing, brackets, straps, bolts, and angles as required to set and connect the work rigidly. Conform to California Building Code requirements.

D. Control erection tolerance requirements so as to not impair the strength, safety, serviceability, or appearance of the installations. Determine exact locations of conduit. Route conduit parallel to building lines unless otherwise indicated.

E. The trade size, type, and general routing and location of conduits, raceways, and boxes shall be as indicated or specified.

F. Install exposed conduit so as to avoid conflicts with other work. Install horizontal raceways close to the ceiling or ceiling beams, and above water or other piping.

G. Use of powder-actuated or explosive fasteners is prohibited.

3.02 CONDUIT AND FITTINGS

A. Electrical Conduit - Installation Requirements:

1. Install conduit in accordance with California Electrical Code, NFPA 70, NFPA 130, and as indicated. Prevent concrete and other materials from entering and obstructing the conduit, outlets, and pull and junction boxes.

2. Conduit labelling shall be as indicated in the Contract Drawings.

3. Conduits shall be labeled with its source, circuit numbers and destination.

4. Spare conduits shall have pull string with tag labeled as spare.

5. Conduits shall be cleaned by using brushes and swabs. Underground PVC and fiberglass direct buried conduits larger than 2-inch diameter shall be tested with 90 percent conduit size mandrel. Testing shall be done in the presence of an authorized BART Representative. Any conduit that does not pass the test shall be replaced and retested at the Contractor's expense. Conduits shall be tested before and after area is paved.

6. Conduits smaller than 3/4-inch shall not be used.

7. Non-Metallic Conduit (NMC) shall be 1-inch or greater for underground and embedded locations. For concrete slabs less than five-inch thick or elevated prestressed concrete decks, 3/4-inch NMC may be used. Bending radius shall not exceed manufacturer's specification.

8. Conduit fill of ENT shall not exceed 30 percent. Junction boxes or pull boxes for ENT shall be spaced no more than 100-feet apart.

9. All flexible conduits, exposed, embedded or concealed shall be fastened every three-feet and 24-inches from a box outlet.

10. Unless otherwise indicated, make conduit bends in accordance with California Electrical Code, with not more than three quarter bends, 270 degrees total, per run of conduit. Where more bends are required in a particular run, install pull boxes as required to facilitate pulling conductors even if not indicated.

11. Terminate metallic conduit installed for future extension with flush threaded couplings set to finished floor level or wall, unless otherwise indicated. Provide plug for open end. Extensions to existing Work shall match existing size.

12. Provide and install metallic numbering tags on both ends of all conduits. Tags shall be marked with a stamped conduit identification number. Conduit tag shall be durable of aluminum or stainless steel material; and permanently tied with stainless steel straps on both sides, either top and bottom or left and right.

13. Properly support and anchor conduit to be embedded to maintain correct location and spacing and to prevent flotation during concreting operations. If necessary, provide suitable metal supports.

14. Install conduit so that moisture collecting in the conduit will be drained to the nearest outlet or pull box. Drill weep-holes at the lowest points in each exposed conduit run. Install a “T” conduit with drain fitting at the lowest point.

15. Whenever exposed or buried conduit passes through an expansion or contraction joint in the structure, install the conduit at right angles to the joint, and provide an approved conduit expansion fitting at the joint. Paint the conduit with an approved bituminous compound for one foot on each side of the expansion couplings.

16. Provide expansion fittings in conduit runs to compensate for thermal expansion.

17. Rod and swab embedded conduit after installation to remove foreign matter. If obstructions are encountered which cannot be removed, or if conditions exist which may result in damage to wires and cables pulled through the conduit, install new conduit at no additional cost to the District.

18. After the conduit has been rodded and swabbed, install covers on boxes and protect conduit ends to prevent foreign material from entering the conduit.

19. Where conduit is exposed to different temperatures, seal the conduit to prevent condensation and passage of air from one area to the other.

20. Metallic conduits shall be electrically and mechanically continuous and connected to ground by bonding to the grounding system.

21. Apply conductive compound to the threads of threaded rigid conduit joints. Do not use compounds containing lead. Terminate the conduit in appropriate boxes at motors, switches, outlets, and junction points.

22. When field cutting of conduit is required, thread and ream the conduit to remove rough edges. Where a conduit enters a box or other fitting, provide a bushing to protect the wire from abrasion. Provide insulation type bushings and double locknuts on ends of rigid conduits terminating at steel boxes, panelboards, cabinets, motor starting equipment, and similar enclosures.

23. Support individual conduits not larger than one inch in diameter by means of one-hole conduit straps with back spacers or individual conduit hangers.

24. Space conduits installed against concrete surfaces one fourth inch away from the surface by clamp backs or other approved means.

25. Support individual conduits larger than one inch in diameter by individual hangers or forged steel two-hole conduit strap.

26. Hanger rods used in connection with spring-steel fasteners, clips and clamps shall be either three eighths-inch diameter galvanized steel rods or, if concealed above a suspended ceiling, galvanized perforated steel strapping. Do not use wire for support of conduit.

27. Support parallel conduits at the same elevation on multiple conduit hangers or channel inserts. Secure each conduit to the pipe hanger or channel insert member by a U-bolt, one-hole strap or other specially designed and approved fastener suitable for use with the pipe hangers or channel inserts.

28. Space supports not over ten feet on centers for vertical conduits spanning open areas. Securely anchor conduit at each end, and run so as not to interfere with the installation and operation of equipment at the location.

29. Support conduits and raceways above suspended ceilings from either the floor construction above or from the main ceiling support members, by using the applicable methods specified herein.

30. Install liquid-tight flexible metal conduit at structural construction joints, at motor connections and where required so that liquids tend to run off the surface and not drain toward fittings. Provide sufficient slack to reduce the effects of vibration. Running threads are not acceptable. Where necessary for connecting to rigid conduits, use right and left hand couplings.

31. In areas of floating slabs, install horizontal runs of conduit beneath the floating slab. Conduit shall pass through the floating slab only where required to terminate in a vertical direction as indicated. Provide a sleeve with an all-around one fourth-inch clearance between sleeve and vertical conduit riser. Fill the space around the conduit with rubber-base waterproofing compound.

32. Electrical metallic tubing (EMT) may be run exposed above 10 feet or concealed in walls and ceilings, where allowed. Do not install EMT in tunnels, subways, traction power substation rooms, utility chase, under-platform utility chase, outdoor locations and exposed to weather. All emergency power and lighting circuits, communication circuits, fire alarms, service entrance, emergency system (vent fans/damper/pumps/generators), and essential loads of train control circuits shall not be installed in EMT. EMT may be used below 10-feet above finished floor for circuits exiting walls or ceilings but shall not have an exposed length exceeding three-feet.

33. Tag unscheduled conduit in a manner acceptable to the District Representative for indoor installations only.

34. Conduits for emergency loads (such as emergency lighting and fire alarm system) shall be run separately from “normal” load conduits and protected from physical damage and shall be GRS.

35. Seal conduits with watertight duct sealing system, where waterproofing is required.

36. Metal clad cable system installations shall comply with NFPA 70, and as modified by NFPA 130.

B. Nonmetallic Conduit:

1. Embed in slabs and walls where indicated.

2. Cap or plug the ends of embedded conduit to prevent concrete and other materials from obstructing the conduit.

3. Sandpaper joints in PVC conduit to remove burrs, clean and dry the joints, and brush with a solvent cement acceptable to the manufacturer before installing.

4. Support conduit to maintain the correct location and spacing during concreting operations and provide suitable plastic supports and spacers for conduit ductbanks.

5. Other installation requirements shall be the same as for metallic electrical conduit.

C. Pull Cords:

1. Provide nylon pull cords of tensile strength not less than 240 pounds in each conduit and duct. Leave pull cords in ducts and conduit.

2. Splices in pull cords will not be permitted.

3. Leave ample slack length at each end of pull cords.

D. Filling of Openings: Wherever slots, sleeves, or other openings are provided in floors and walls for the passage of raceways, conduits, and bus ducts, fill such openings as follows:

1. Provide fire-resistive filling material and installation for openings in conformance with Section 07 84 00, Firestopping.

2. Where conduits passing through openings are exposed in finished rooms, use surface filling material that matches, and is flush with, the adjoining finished floor, ceiling, or wall.

E. Conduit Hangers:

1. Provide anchor bolts and anchorage items as required, and field check to ensure proper alignment and location. Provide templates, layout drawings, and supervision at the jobsite to ensure correct placing of anchorage items in concrete. Check embedded items for correctness of location and detail before concrete is placed.

2. Install supporting members, fastenings, framing, hangers, bracing, brackets, straps, bolts, and angles as required to set and connect the work rigidly. Conform to California Building Code requirements for Seismic Zone 4 location.

3. Support parallel conduits at the same elevation on multiple conduit hangers or channel inserts. Secure each conduit to the hanger or channel insert member by U-bolt, one-hole strap, or other specially designed and approved fastener suitable for use with the hangers or channel inserts.

4. Space supports not over 10 feet on center for vertical conduits spanning open areas. Securely anchor conduit at each end, and run so as not to interfere with the installation and operation of equipment at the location.

5. Support conduits and raceways above suspended ceilings from either the floor construction above or from the main ceiling support members, by using the applicable methods specified herein.

F. RTRC, Fittings, and Accessories:

1. Clean and sand to remove contaminations as recommended by manufacturer for onsite preparation procedures for fitting and conduit joints.

2. Epoxy adhesive mix nozzle supplied with the kit shall not be altered in any way and shall be disposed and replaced with a new tip for every six (6) joints.

3.03 INSERTS

A. Channel Inserts: Install embedded channel inserts with the slotted face flush with the finished concrete surface.

B. Spot Inserts: Install with the insert face flush with the finished concrete surface, firmly embedded, with no evidence of movement.

C. Tests: Test selected inserts by suspension of 800 pounds of weight from the insert. If there is evidence of failure, replace the inserts in a satisfactory manner at no additional cost to the District, and retest.

3.04 SURFACE METAL RACEWAYS

A. Install surface metal raceways, where indicated, in accordance with California Electrical Code. Use fittings and accessories designed for the raceway.

B. Securely ground surface metal raceways to outlet boxes or to backplates and fixtures by means of bolts, screws, or other approved method and as specified in Section 26 05 26, Grounding and Bonding for Electrical Systems.

3.05 OUTLET, JUNCTION, AND PULL BOXES

A. Mount outlet, junction, and pull boxes so as to prevent moisture from entering or accumulating within the boxes. Mount boxes opposite to the third rail wherever possible. Do not use conduits entering the box as supports for the box.

B. Outlet Boxes:

1. Unless otherwise indicated, flush mount outlet boxes with the front edges of the boxes or tile covers attached thereto flush with the finished wall or ceiling.

2. Mount boxes so that the long axis of the devices will be vertical, unless otherwise indicated.

3. Locate boxes and box knockouts in concrete so as not to interfere with the reinforcing steel.

4. Unless otherwise specified, provide boxes in tile walls and ceilings with tile covers. Do not install these covers until the finished tile line is determined for the particular location.

5. The mounting height indicated for a wall-mounted outlet box shall be construed to mean the height from the finished floor to the horizontal centerline of the cover plate.

6. Mount outlet boxes for switches and receptacles located on columns and pilasters so as not to interfere with installation of partitions.

7. Install boxes located near doors on the lock side, even where the symbols appear on the hinge side as indicated, unless other locations are approved by the Engineer.

C. Junction and Pull Boxes:

1. Install so that covers are readily accessible after completion of the installation.

2. Do not install boxes above suspended ceilings, except where the ceiling is of the removable type or where definite provisions are made for access to each box.

D. Boxes Set in Concrete:

1. Support boxes to prevent movement during placement of concrete.

2. Unused nailing holes or other holes in the side or bottom of the boxes shall be plugged or masked.

3. After installation, clean boxes placed in concrete and provide covers to prevent entry of dirt and debris.

3.06 CABLE TRAYS

A. Install cable trays as indicated and in accordance with California Electrical Code, Article 392, using approved fittings and adequately supporting the complete system.

B. Provide anti-sway brackets on horizontal tray assemblies at 10 foot intervals.

C. Connect each isolated cable tray system or the entire tray system to the building equipment grounding system with a bare copper conductor in accordance with California Electrical Code.

D. Base size determination of grounding cable on the largest power and control conductor in the cable tray:

1. Minimum size: 14 AWG.

2. Maximum size: 750 kcmil.

3.07 UNDERFLOOR DUCTS AND FITTINGS

A. Install duct systems in the station finish floor as indicated.

B. Join duct sections using sleeve-type couplings, and fasten to station structure with expansion bolts as indicated. Hold-down straps shall maintain a one-inch space between the two ducts.

C. Seal duct installations watertight with an approved sealing compound before concrete pour.

3.08 POLYMER CONCRETE CABLE TROUGH

A. High density polymer concrete cable troughs shall be installed in ballast or soil, and mounted on or fixed to horizontal surfaces.

B. Adhere to approved methods for excavation and backfill. Heavy duty hydraulically operated equipment shall not be used.

C. Install such that adjacent cable trough units are flush horizontally and vertically without gaps in-between or vertical separation.

D. Prior to installation of cables and wires, clean cable trough of debris.

E. Cable troughs shall be installed per the manufacturer’s installation instructions and recommendations.

END OF SECTION 20 50 13

SECTION 20 50 16

UNDERGROUND DUCTWORK AND STRUCTURES FOR FACILITY SERVICES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Reinforcement steel for ductworks.

B. Conduit.

C. Pre-cast concrete structures.

D. Sand.

E. Cast-in-place concrete ductbank and structures.

F. Frames, covers, gratings, steps and sumps.

G. Cover identification.

1.02 RELATED SECTIONS

A. Section 20 50 13, Raceways for Facility Services

B. Section 03 05 15, Portland Cement Concrete

C. Section 03 30 00, Cast-in-Place Concrete

D. Section 03 20 00, Concrete Reinforcing

E. Section 20 70 26, Common Materials and Methods for Electrical Systems

F. Section 32 11 24, Aggregate Drainage Layer

G. Section 33 05 16, Utility Structures

H. Section 33 05 28, Trenching and Backfilling for Utilities

1.03 MEASUREMENT AND PAYMENT

A. General: Underground ductwork and structures, as specified herein, will not be measured separately for payment but will be paid for as part of the Contract lump sum price for the related item of work as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM C33/C33M Standard Specification for Concrete Aggregates

2. ASTM F512 Standard Specification for Smooth-Wall Poly (Vinyl Chloride) (PVC) Conduit and Fittings for Underground Installation

1.05 REGULATORY REQUIREMENTS

A. California Code of Regulations, Title 24, Part 3, California Electrical Code

B. State of California Public Utilities Commission (CPUC):

1. CPUC General Order (G.O.) 128, Rules for Construction of Underground Electric Supply and Communications Systems

C. Refer to Section 20 70 26, Common Materials and Methods for Electrical Systems, for additional requirements.

1.06 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings:

1. Submit Shop Drawings for fabrication and installation of pre-cast concrete structures, cast-in-place concrete structures, and concrete-encased underground ductwork, including the following:

   a. Excavation and shoring plans with required structural calculations;

   b. Cast-in-place and pre-cast detailed steel reinforcement drawings; and

   c. Cast-in-place and pre-cast manufacturer’s concrete mix designs for structures and colored concrete as indicated.

2. Shop drawing information may be combined on a single drawing if clarity is not thereby impaired.

3. Shop Drawings shall fully demonstrate that the work to be performed and the materials to be provided comply with the provisions of these Specifications.

C. Product Data: Submit the following:

1. Complete materials list of items proposed to be furnished and installed under this Section.

2. Manufacturers' specifications and other data required to demonstrate compliance with these Specifications.

3. Catalog cuts for the following products:

   a. Conduits.

   b. Underground duct system, including manholes, pull boxes, handholes, cable junction boxes, and termination boxes.

   c. Manhole, pull box, and handhole covers and frames.

   d. Related miscellaneous hardware and metal items for cable trenches and wireways.

   e. Trench and wireway covers including composition of FRP materials, divider partition panels, method of joining sections, expansion joint mounting, and support details.

D. Certificates of Compliance: Provide for all specified products.

1.07 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with the California Electrical Code, and CPUC General Order No. 128. In case of conflict between the California Electrical Code and CPUC G. O. 128, the provisions of CPUC G.O. No. 128 shall govern.

B. Qualification of Manufacturers:

1. Manufacturers of the products specified for work under this Section shall be in the business of manufacturing similar products and shall be able to provide a history of successful production of the specified products.

2. Submit a list of five major projects, where similar products have been supplied, which have been in satisfactory use or operation for the past five years.

C. Notifications and Inspection: Completed facilities shall be approved by the Engineer before installation of cable and equipment. Corrective work required to obtain approval of underground construction and ductwork shall be performed at no additional cost to the District.

1.08 SITE CONDITIONS

A. Before beginning construction or installation of a section of underground conduit or ductwork, verify that the site is in suitable condition for installing such conduit or ductwork as indicated.

B. During non-work hours and at locations where installation of conduits and ducts is temporarily suspended or terminated, close ends of ducts with caps or plugs fitted to prevent entry of water or debris. Use caps or plugs designed for that purpose by the conduit manufacturer.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Reinforcement Steel for Ductbanks:

1. Provide longitudinal reinforcing steel with a minimum total cross sectional area of 0.0018 times the gross area of the ductbank. Maximum spacing of reinforcement bars shall be 18 inches; minimum of one bar in each corner of ductbank.

2. Provide steel tie bars in the transverse direction enclosing the longitudinal bars; minimum size of No. 3 bars; minimum spacing of 12 inches. Minimum clear concrete cover over reinforcement steel shall be three inches where concrete is cast directly against earth, and one and a half inches where concrete is cast directly against formwork.

3. Where ductbank enters rigid underground structures, provide reinforcing steel to tie the ductbank to the structure. Provide details indicating method employed to prevent differential settlement from damaging ductbanks.

B. Conduit: Conform with ASTM F512. Provide PVC conduit, minimum Schedule 40, and all necessary fittings in sizes as indicated. Provide flared bell ends on conduits and ducts entering manholes, handholes, and pull boxes.

C. Pre-cast Concrete: Provide pre-cast concrete structures in accordance with requirements of Section 33 05 16, Utility Structures, and as indicated.

1. Pre-cast concrete electrical boxes, pull boxes, ground rod boxes, manholes, handholes, and vaults shall be provided as indicated. Concrete reinforcement shall be that which is regularly provided in standard products of the manufacturer. Standard manufactured structures that meet project requirements will be acceptable. Provide concrete inserts for mounting cable support brackets as indicated.

2. Pull box tops shall be flush with sidewalks or curbs or placed one and a half inches above surrounding grades when remote from curbed roadways or sidewalks. Covers shall be provided with two lifting eyes and two hold-down bolts. Each box shall have a suitable opening for a ground rod, and a drainage opening.

D. Sand: Sand for filler material, where indicated, and for bedding of conduit in utility trenches shall be a clean and graded, washed sand, all passing a No. 4 U.S. sieve, and conforming generally to ASTM C33/C33M for fine aggregate.

E. Cast-In-Place Concrete for Ductbank Encasements, Manholes, Pull Boxes, and Vaults:

1. Concrete shall be Class 3000 in accordance with Section 03 05 15, Portland Cement Concrete, for ductbank encasements, manholes, pull boxes, and vaults. Concrete for ductbank encasements for conduits carrying circuits rated above 600 volts shall be colored red as specified in Section 03 05 15, Portland Cement Concrete.

2. Formwork and concrete placement shall conform with applicable requirements of Section 03 11 00, Concrete Forming, and Section 03 30 00, Cast-in-Place Concrete.

3. Reinforcing steel, as indicated, shall conform with applicable requirements of Section 03 20 00, Concrete Reinforcing.

F. Frames, Covers, Gratings, Steps and Sumps: Provide as indicated and in accordance with Section 33 05 16, Utility Structures.

G. Yellow Warning Tape: Polyethylene Heavy Gauge 4 mil thick tape with “Buried Electrical Line Below.”

H. Cover Identification: Provide covers with embossed or engraved identification as indicated and as specified in Section 33 05 16, Utility Structures.

PART 3 – EXECUTION

3.01 EXCAVATION, TRENCHING AND BACKFILLING

A. Perform excavation, bedding, and backfilling for underground conduits and structures in accordance with Section 33 05 28, Trenching and Backfilling for Utilities, and as indicated.

3.02 INSTALLATION

A. Underground Duct System: Install as indicated. Conduit, pull boxes, and manholes shall be located as indicated. Comply with applicable requirements of CPUC G.O. 128.

B. Ducts:

1. Inspect ducts and couplings to ensure that only clean and undamaged pieces are incorporated in the work.

2. Ductbanks or conduits shall interface with building construction five feet outside of the building and shall have a minimum slope of three inches to each 100 feet away from buildings and towards manholes, pull boxes, and handholes, and shall run in straight lines between indicated changes in direction.

3. Individual conduits that are grouped together to form a ductbank shall conform to the standards and requirements specified herein.

4. Horizontal or vertical changes in direction exceeding ten degrees shall be accomplished by long sweep bends having a minimum radius of curvature of 25 feet, except that manufactured bends may be used at ends of short runs of 100 feet or less, and then only at or within five feet of the end of the run. Sweep bends may be made up of curved or straight sections, or combinations thereof. Manufactured bends shall have a minimum radius of 36 inches for ducts of three inches in diameter and larger.

5. Conduits shall terminate in end-bells where duct lines enter vaults.

6. Spacers or space separators shall be placed not more than 6 feet apart, and shall transmit no vertical load to the conduit.

7. Install ducts, joints, and space separators according to manufacturer's printed instructions and recommendations.

8. During construction, partially completed duct lines shall be protected from the entrance of debris by means of suitable caps or plugs. As each section of a duct line is completed between manholes, handholes, or pull boxes, a testing mandrel not more than one fourth inch less than the size of the conduit shall be drawn through each conduit, after which a brush with stiff bristles shall be drawn through until the conduit is clear of particles of earth, sand, or gravel. Conduit caps or plugs shall then be immediately installed.

9. Construct the concrete-encased ductbank with three-inch minimum cover on all sides. The concrete used for the ductbank containing circuits over 600 volts shall be integrally colored with a red mineral coloring pigment as specified in Section 03 05 15, Portland Cement Concrete.

10. Install 1/8 inch or larger diameter polypropylene pulling cord in ducts including innerducts. Fasten each cord to pull iron anchorage in pull box, manhole, or vault with 2 feet minimum slack.

11. Innerduct placement in communications conduits shall be performed to avoid excessive tension and deformation of the innerduct. Damaged or necked down innerduct shall be replaced. Conform with the manufacturer's installation instructions.

12. Provide metallic numbering tags indicating the conduit number on both ends of all conduit runs.

C. Yellow Warning Tape: Tape shall be installed six inches above the top of concrete ductbank and the vertical center line of its cross section

D. Pre-cast Concrete Structures: Install pre-cast electrical boxes, pull boxes, handholes, manholes, and vaults as indicated. Boxes shall be placed on four inches of compacted sand bedding. Manholes shall be placed on six inches of compacted aggregate base as specified in Section 32 11 24, Aggregate Drainage Layer. Conduit, cable, ground rod entrances, and unused openings shall be sealed with cement mortar.

E. Cast-In-Place Concrete Structures:

1. The location of each pull box, manhole, and vault shall be approved by the Engineer before construction of such structure is started. Top, walls, and bottom shall consist of reinforced concrete. Walls and bottom shall be of monolithic concrete construction.

2. Place concrete for pull boxes, manholes, and vaults on well-compacted soil with a minimum of 6 inches of aggregate base as specified in Section 32 11 24, Aggregate Drainage Layer. Seal all sumps. Frames and covers shall be of gray cast iron. A machine-finished seat shall be provided to ensure a matching joint between the frame and cover.

3. Where duct lines enter pull boxes, manholes, and vaults, the sections of duct may be either cast in the concrete or may enter through a square or rectangular opening of suitable dimensions provided in the utility structure. A cable-pulling iron anchorage shall be installed in the wall opposite each ductbank entrance.

END OF SECTION 20 50 16

SECTION 20 60 13

MOTORS FOR FACILITY SERVICES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Motor, appurtenances, and accessories.

1.02 RELATED SECTIONS

A. Coordinate with Sections in other Specifications for equipment requiring electrical motors.

B. Section 20 50 13, Raceways for Facility Services

C. Section 26 05 24, Low Voltage Wires and Cables

D. Section 26 05 26, Grounding and Bonding for Electrical Systems

1.03 MEASUREMENT AND PAYMENT

A. General: Motors, as specified herein, will not be measured separately for payment but will be paid for as part of the Contract lump-sum price for the related item of work as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM A582/A582M Standard Specification for Free-Machining Stainless Steel Bars

B. National Electrical Manufacturers Association (NEMA):

1. NEMA MG 1 Motors and Generators

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit electrical diagrams of wiring, circuits, switches, and control panels.

C. Product Data: Submit manufacturer’s product data and physical descriptions of electrical motors, including ratings and performance characteristics.

D. Test Reports: Submit certified test reports of factory tests performed on each motor, in accordance with NEMA MG 1.

E. Field Test Reports: Submit test results of field performance tests.

F. Operation and Maintenance Data: Submit O&M data in accordance with Section 01 78 23, Operation and Maintenance Data. Submittal shall include the following information:

1. Description of motor and its components.

2. Manufacturer's operating and maintenance instructions, parts list, illustrations, and diagram for components.

3. Recommended list of spare parts.

4. Wiring diagram.

5. Speed-torque curve.

6. Outline and base dimensions.

1.06 DELIVERY, STORAGE AND HANDLING

A. Ship motors securely wrapped, crated or packaged, and labeled for safe handling in shipment and to avoid damage.

B. Store motors in secure and dry storage facility.

PART 2 – PRODUCTS

2.01 MOTOR, APPURTENANCES, AND ACCESSORIES

A. Manufacturing Standards: NEMA MG 1, squirrel cage induction type, unless otherwise indicated. Provide nameplate on each motor in accordance with NEMA MG 1, Section 10.37.

B. Ratings:

1. Horsepower (hp): as indicated.

2. Voltage and Frequency:

a. 1/2 hp and less: 115 V, single phase, 60 Hz supply.

b. 3/4 hp up to and including 100 hp: 460 V, three-phase, 60 Hz supply, unless otherwise indicated.

c. Above 100 hp: 4160 V, three-phase, 60 Hz supply, unless otherwise indicated.

3. Speed and Number of Poles: As indicated.

4. Time Rating: Continuous, unless otherwise indicated.

5. Operation: Suitable for operation at variation of frequency and voltage of plus or minus ten percent of rating without damage.

C. Design Letters:

1. Single Phase Motors: Design N, suitable for full voltage across-the-line starting.

2. Three Phase Motors: Design B, unless otherwise indicated, and suitable for full voltage across-the-line starting.

D. Service Factor:

1. Up to and including one hp motor: NEMA MG 1, Section 12.47.

2. Above one hp and up to and including 200 hp motors: 1.15.

3. Above 200 hp motors: 1.15.

E. Insulation: Class B for operation in an ambient temperature of 40 degrees Celsius. Provide epoxy encapsulated except for fractional horsepower motors, hermetically sealed and semi-hermetically sealed compressor motors.

F. Noise Level: NEMA MG 1, Section 12.49, but not to exceed CAL/OSHA requirements.

G. Energy Efficiency: Motor shall be copper-wound premium efficiency type, with efficiency of 95 percent or higher.

H. Enclosure: Drip-proof fully-guarded or totally-enclosed fan-cooled-guarded as indicated, with the following additional requirements:

1. Heavy-duty steel or cast iron frame with cast iron end brackets.

2. Foot-mounted on pad or adjustable pad as required or otherwise indicated.

3. Provision for grounding.

4. Red oxide zinc chromate primer with finish coat of heavy-duty industrial polyurethane enamel in gray color as selected by the District Representative.

5. Provide drain plug for condensate drainage.

6. Enclosures for motors installed in hazardous areas shall be of group and class approved for the type of hazard in which they are located.

I. Conduit Box: Cast iron diagonally split type, suitably gasketed, with the following additional requirements:

1. Size suitable to accommodate the motor leads, line leads and connections to heaters, including taping, but not less than required by NEMA MG 1.

2. Rotatable in any of the four 90 degree positions.

3. Threaded conduit holes.

J. Bearings: 15 years' average life, but not less than three years at continuous operation, with double shields and the following additional requirements:

1. Up to and including five hp Motors: Sealed ball or roller bearings, unless otherwise indicated.

2. Above five hp and up to 200 hp Motors: Ball or roller bearings with grease fittings and minimum pressure-relief fittings for in-service lubrication.

3. Compressor and Vertical Pump Motors: As indicated.

K. Motors for Hermetically Sealed and Semi-hermetically Sealed Compressors: NEMA MG 1, Sections 18.76 through 18.93.

L. Motors for Close-Coupled Pumps: Stainless steel shaft in accordance with ASTM A582/A582M, Type 303.

M. Heaters: Provide as indicated and wired to the conduit box.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Wire and connect motors in accordance with the manufacturer's instructions and recommendations and as indicated.

B. Install conduit in accordance with Section 20 50 13, Raceways for Facility Services.

C. Connect power cable as indicated and in accordance with Section 26 05 24, Low Voltage Wires and Cables.

D. Ground motor enclosure in accordance with Section 26 05 26, Grounding and Bonding for Electrical Systems.

E. Provide liquid tight flexible metal conduit connection at motor.

3.02 FIELD QUALITY CONTROL

A. Conform to applicable requirements of Section 01 45 24, Testing Program Requirements.

B. Perform the following tests under the observation of the Engineer. Furnish equipment, instruments, and measuring devices as required to perform the tests. Tests shall be performed with motor connected to its permanent source of power.

1. Test circuits for connections in accordance with the wiring diagram. Test motors for correct rotation. Disconnect motor shaft from driven machine if damage may be caused by incorrect rotation.

2. Test that insulation resistance to ground of non-grounded conductor is a minimum of 10 MΩ.

3. Test motor enclosure for continuity to the grounding system.

4. Test operation of circuits and controls for motors. When testing, operate each control a minimum of ten times and each circuit continuously for a minimum of 1/2 hour.

END OF SECTION 20 60 13

SECTION 20 70 13

COMMON MATERIALS AND METHODS FOR ELECTRONIC SERVICES

PART 1 –GENERAL

1.01 SECTION INCLUDES

A. Interconnect panels

B. Outlets, hardware, and connections

C. Fiber optics jumpers

D. Innerducts

1.02 MEASUREMENT AND PAYMENT

A. General: Common materials and methods for electronic services, as specified herein, will not be measured separately for payment but will be paid for as part of the Contract lump-sum price for the related items of work in the Bid Schedule of the Bid Form.

1.03 REFERENCES

A. The Institute of Electrical and Electronics Engineers, Inc. (IEEE):

1.	IEEE	National Electrical Safety Code (NESC)

B. California Code of Regulations, Title 24, Part 3

C. Electronic Components Industry Association (ECIA)/Telecommunications Industry Association (TIA):

1.	ECIA EIA/ECA-310-E	Cabinets, Racks, Panels, and Associated Equipment
2.	TIA 455-11-D	FOTP-11 Vibration Test Procedure for Fiber Optic Components and Cables
3.	TIA-568.1-D	Commercial Building Telecommunication Infrastructure Standard
4.	TIA-606-B	Administration Standard for Telecommunications Infrastructure

D. National Fire Protection Association (NFPA):

1.	NFPA 262	Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air Handling Spaces
2.	NFPA 70	National Electrical Code

E. Underwriters Laboratories, Inc (UL)

F. American Society for Testing and Materials (ASTM):

1. ASTM A500/A500M Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes

1.04 SUBMITTALS:

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Product Data and Catalog Cuts: Data and catalog cut for each specified product shall be submitted.

C. Samples: Samples of materials specified herein shall be submitted, upon request by the District.

D. Certificates: Manufacturer's certificate indicating compliance with specified requirements. Where equipment or materials are specified to conform to the standards or publications and requirements of CFR, NFPA, ECIA/TIA, or UL, certificates attesting compliance to said standards or publications shall be submitted.

PART 2 –PRODUCTS

2.01 GENERAL

A. Furnish materials and equipment of design, sizes, and ratings as indicated.

B. Furnish materials and equipment bearing label or classification listing of a national recognized testing laboratory where UL standards exist and such product labeling or listing is available.

C. Provide products that are free from defects that may impair performance, durability, or appearance.

2.02 INTERCONNECT PANELS

A. Patch panels shall be a complete system of components fabricated by a single manufacturer, and shall provide termination, splice storage, routing, radius limiting, cable fastening, storage, and cross-connection of fiber optic cables. Patch panels shall be 19 inch rack mounted panels. Patch panels shall provide strain relief for cables. Panels shall be labeled with alphanumeric x-y coordinates and shall be provided with labeling space. Patch panels shall be fully populated with connector modules in the quantities indicated.

2.03 OUTLETS, HARDWARE, AND CONNECTIONS:

A. Station Agent's Booth. Telecommunication outlet for Station Agent's Booth fiber cable termination shall be a flush-mounted wall box with faceplates equipped with six fiber optic ST to LC compatible sleeve connectors. Faceplates shall be stainless steel double gang.

B. Destination Sign Units (DSU): Sign hangers shall be constructed of ASTM A500/500M Grade B structural steel tubing.

C. Automatic Fare Collection (AFC) Equipment: Telecommunication outlet for AFC equipment fiber cable connection shall be a Designated Matching Product. Three dual LC to LC connector sleeve insert modules, Designated Matching Products, shall be furnished for each AFC equipment outlet.

2.04 FIBER OPTIC JUMPERS

A. Patch cords shall be cable assemblies consisting of flexible optical fiber cable equipped with compatible connectors. Patch cords shall be complete assemblies from manufacturer's standard product lines. Length shall be as required. Fiber optic jumper cables shall meet the following requirements:

1. Fiber optic jumper cables shall be two-fiber zip cord type.

2. Cable construction shall allow a small bend radius for installation in space constrained areas. The cable shall contain a dielectric strength member and a protective outer jacket. The fiber core size shall be identified on the outer jacket

3. Fibers shall be terminated at each end with connectors as specified herein.

4. Cables shall meet the requirements specified in Section 20 70 23, Electronic Circuits, Wires, and Cables.

2.05 INNERDUCTS

A. Inner ducts shall be corrugated semi-ridged construction, low smoke, zero halogen material, and shall have an inner diameter of no less than one and a quarter inches and no more than two inches. Couplers, if used, shall not reduce the inside diameter of the inner duct.

PART 3 –EXECUTION

3.01 GENERAL

A. System components and appurtenances shall be installed in accordance with NFPA 70, manufacturer's instructions and as indicated. Necessary interconnections, services, and adjustments required for a complete and operable signal distribution system shall be provided. Components shall be labeled in accordance with

TIA-606-B. Penetrations in fire-rated construction shall be sealed with fireproof material.

B. Cabling shall be installed in accordance with TIA-568.1-D and as specified herein. Cabling, distribution panels, terminal blocks, and outlets shall be marked in accordance with TIA-606-B. Cables not installed in conduit or wire ways shall be properly secured and neat in appearance and, if installed in plenums or other spaces used for environmental air, shall comply with NFPA 70 requirements for this type of installation.

3.02 TESTING

A. Refer to Section 01 45 24, Testing Program Requirements, for requirements governing test plans, procedures, and results.

1. Factory Tests: Tests shall be performed on each deliverable assembly at the Contractor's and each sub-supplier’s facility prior to shipment.

END OF SECTION 20 70 13

SECTION 20 70 19

INDOOR CABINETS, RACKS, FRAMES, AND ENCLOSURES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Equipment cabinets

B. Cable entrance cabinets

C. Cabinet identification

1.02 RELATED SECTIONS

A. Interface and coordinate the work of this Section with Section 20 70 26, Common Materials and Methods for Electrical Systems, and Section 20 70 13, Common Materials and Methods for Electronic Services.

1.03 MEASUREMENT AND PAYMENT

A. General: Indoor cabinets, racks, frames, and enclosures, as specified herein, will not be measured separately for payment but will be paid for as part of the Contract lump sum price for the related item of work as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. Electronic Components Industry Association (ECIA):

1. ECIA EIA/ECA-310-E Cabinets, Racks, Panels, and Associated Equipment

B. American Railway Engineering and Maintenance-of-Way Association (AREMA):

1. Communications and Signal Manual, Section 1 Part 1.5.10 Recommended Instructions for Painting and Protective Coatings

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Submit the following:

1. Product data for equipment cabinets.

2. Shop drawings.

3. Cabinet mounting details.

4. Cabinet paint types and colors.

PART 2 – PRODUCTS

2.01 MANUFACTURING REQUIREMENTS

A. Equipment Cabinets: Equipment in communication rooms and train control rooms/houses shall be housed in free standing cabinets conforming to the following requirements:

1. General. Cabinet frame shall be constructed of No. 14 American Wire Gauge (AWG) cold rolled steel. Cabinet construction shall be as shown in the Contract Drawings.

2. Cabinet structures shall have uniform dimensions. ATC equipment cabinets shall not exceed 48 inches in width and 24 inches in depth. A cabinet complex shall not exceed 72 inches in width.

3. Enclosures: Cabinet enclosures shall be furnished complete. The front and rear of the cabinets shall be enclosed with captive full-length doors opening at least 120 degrees, closed with hand-operated key-locked catches, and with louvered openings, if required. Doors shall be removable without unscrewing.

   a. Cabinets shall be designed for side-by-side mounting with provisions for running interconnection wiring within a complex in closed wire way between cabinets.

   b. All non-used front spaces of cabinets shall be covered with blank panels.

   c. Self-ventilation of cabinet enclosures shall be used. If fans or filters are required, shop drawings shall be submitted for approval before manufacture.

4. Cabinet Hardware: Cabinets and appurtenances shall be designed and constructed to comply with ECIA EIA/ECA-310-E. The frame weldment shall be designed to accept universally adjustable panel-mounting hardware. The panelmounting angles shall be constructed of No. 12 AWG cold rolled steel with standard EIA hole spacing and structured to comply with ECIA EIA/ECA-310-E.

5. Cable Entry: Cable entry shall be through the top of the cabinet. Cable entry shall have provisions for protecting the cable. Cables shall be routed to protect them from damage during and after installation.

6. Terminal Block Mounting Board: Mounting boards for terminal blocks and other items as required shall be made from flame retardant non-metallic, non-wood, insulating sheet material approved by the District.

7. Supports: Chassis supports or guides shall be provided as required for auxiliary support of heavy equipment and for PC card files or non-vital relay modules.

8. Height: Overall cabinet height shall be uniform and shall not exceed 7 feet, 2 inches, including mounting sill.

B. Cable Entrance Cabinets: Cable entrance cabinets shall be equipped with front full-length removable doors with key-locked catches opening at least 120 degrees. The rear of the cabinet shall be accessible by a bolted removable panel or full-length removable door. The structure shall not exceed 60 inches in width or 24 inches in depth. Cable entrance cabinets shall meet the requirements specified for equipment cabinets, with the exception of cabinet dimensions and door construction. Cable entrance cabinets shall be installed as indicated on the Contract Drawings.

C. Painting: Cabinets shall be painted in accordance with the requirements of Section 09 91 00, Painting, as modified herein.

1. Train control equipment cabinets and racks shall be painted light gray with color number 2.5R/7N as selected from the Munsel Color Chart. Exterior rack surfaces shall have a textured finish.

2. Communications equipment cabinets shall be painted light blue conforming to Sinclair Chromatic and Sintone Color System for Sinclair Code CM 8751(light blue).

3. Quality: Painting shall conform to the requirements specified in AREMA Communications Signal Manual, Section 1 Part 1.5.10, or equivalent. Paint types and colors shall be submitted for approval.

D. Cabinet Identification: Each equipment cabinet/enclosure shall be provided with I.D. Nameplates. Free standing cabinets/enclosures shall be provided with two nameplates, one for the front and one for the rear. Wall mounted cabinets/enclosures shall be provided with one nameplate on the front. Nameplates shall be of a sixteenth of an inch-thick lamicoid, with beveled edges, black background and white letters. Mounting hardware shall be stainless steel.

1. Nameplate sizes:

   a. Nameplates one and nine sixteenths of an inches high by 18 or 12 inches wide shall have lettering in block letters a half inch high.

   b. Nameplates three fourths of an inch high by 12 inches wide shall have lettering in block letters three sixteenths of an inch high.

2. Nameplate text shall consist of two lines, unless otherwise approved by the District. The first line shall denote the cabinet/enclosure number, and the second line shall denote the name of the cabinet/enclosure.

3. Train Control equipment cabinet numbers shall consist of one letter to denote line location, digits to denote station location, and one or two digits to denote the cabinet number. For example, W20-R14 denotes the following:

W	20	R14
West Bay	South San Francisco	Interlocking Cabinet

a. Location Control Number: The first three characters (W20) in the preceding example shall correspond to the location control numbers assigned to station, TCR, or TCH locations as indicated on the Contract Drawings.

b. Cabinet Number: The cabinet number (14) in the preceding example shall correspond to the cabinet numbering indicated on the Contract Drawings, and shall be preceded by an R.

4. Communications cabinet name and number shall correspond with the designations indicated on the Contract Drawings.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Cabinet Mounting: Cabinets shall be mounted in accordance with BART Seismic Criteria. Provide four and a half inches of fiberglass I beam cabinet mounting sills. The sill structure shall be closed on four sides. Each sill structure shall be leveled to a maximum deviation not exceeding an eighth of an inch over its total length and width.

1. The equipment cabinets shall be mounted rigidly such that a 100-pound horizontal force applied to either side 6 feet from the floor shall cause less than 1/8-inch deflection of any part of the equipment cabinet. Cabinets shall be mounted plumb and level using captive shims as required.

2. In addition to the cabinet deflection, a one sixteenth-inch deflection shall be allowed by the mounting channels after being rigidly mounted to the floor. Equipment cabinets shall be attached together but isolated one from the other and from the floor with insulating material. The equipment cabinet mounting details shall be submitted for approval.

3. Cabinet fronts in adjacent rows shall face each other.

B. Cabinet Grounding: Cabinet-grounding requirements including sill insulation and isolation between cabinets shall be as shown on the Contract Drawings.

END OF SECTION 20 70 19

SECTION 20 70 23

ELECTRONIC CIRCUITS, WIRES, AND CABLES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Optical transmission cable.

B. Non-IP telephone cables.

C. Video cable.

D. Multiple conductor control cables.

E. Thermocouple cables.

F. Ethernet cable.

G. Radio cable.

H. Public Announcement (PA) Cable.

1.02 RELATED SECTIONS

A. Interface and coordinate the work of this Section with:

1. Section 20 70 26, Common Materials and Methods for Electrical Systems.
2. Section 20 50 13, Raceways for Facility Services.
3. Section 26 05 24, Low Voltage Wires and Cables.
4. Section 20 70 13, Common Materials and Methods for Electronic Services.
5. Section 27 13 01, Communication Cables and Related Equipment.

1.03 MEASUREMENT AND PAYMENT

A. General: Electronic circuits, wires, and cables, as specified herein, will not be measured separately for payment but will be paid for as part of the Contract lump-sum price for the related item of work in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM E662 Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials

B. California Code of Regulations (CCR):

1. CCR Title 24, Part 3, California Electrical Code

C. Telecommunications Industry Association (TIA):

1. TIA-606	Administration Standard for the Telecommunications Infrastructure

D. Insulated Cable Engineers Association, Inc. (ICEA):

1. ICEA S-84-608	Telecommunications Cable Filled, Polyolefin Insulated, Copper Conductor Technical Requirements

E. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE 383	IEEE Standards for Qualifying Electric Cables and Splices for Nuclear Facilities

F. National Electrical Manufacturers Association (NEMA):

1. NEMA WC 70	Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy
2. NEMA WC 71	Nonshielded Cable Rated 2001-5000 V for Use in the Distribution of Electrical Energy
3. NEMA WC 74	5-46 kV Shielded Power Cable for Use in the Transmission and distribution of Electric Energy

G. Rural Electrification Administration (REA):

1. REA Bulletin	Specification for Filled Telephone Cable 1753F-205

H. Underwriters Laboratories (UL):

1. UL 1581	Reference Standard for Electrical Wires, Cables, and Flexible Cords
2. UL 1666	Standard for Test for Flame Propagation Height of Electrical and Optical Fiber Cables Installed Vertically in Shafts

I. Engineering Science Data Unit (ESDU):

1. ESDU 06018	Temperature Measurement: Thermocouples

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Submittal Requirements: Before installation of wires and cables, submit the following applicable information for each type and size of wire and cable.

1. Manufacturer of wire and cable, and certificate of compliance;

2. Number and size of strands composing each conductor;

3. Conductor insulation composition type in accordance with California Electrical Code and thickness in mils;

4. Average overall diameter of finished wire and cable;

5. Minimum insulation resistance in megohms per 1000 feet at 30 degrees Celsius ambient;

6. Jacket composition and thickness in mils;

7. Total number of conductors per cable;

8. Shield material (if any) and thickness;

9. Conductor resistance and reactance in ohms per 1000 feet at 25 degrees Celsius ambient; and

10. Conductor ampacity at 30 degrees Celsius ambient for 600 V wire and cable, 20 degrees Celsius ambient earth temperature, 100 percent load factor and conductor temperature of 90 degrees Celsius for wire and cable rated two kV to five kV.

C. Fiber optic Cable Samples: For fiber optic cables, a 100-foot sample of each optical cable type, single mode and multimode, of the respective sizes indicated, shall be submitted together with full technical specifications for each cable design and construction.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Provide markings on wire and cable in accordance with applicable NEMA and California Electrical Code requirements. Each item shall be labeled with UL listing approval.

B. Ship each unit securely wrapped, packaged, and labeled for safe handling in shipment and to avoid damage.

C. Store wire and cable in secure and dry storage facility.

PART 2 – PRODUCTS

2.01 OPTICAL TRANSMISSION CABLE

A. Refer to Section 27 13 01, Communication Cables and Related Equipment.

2.02 TELEPHONE CABLES

A. Refer to Section 27 13 01, Communication Cables and Related Equipment.

2.03 VIDEO CABLES

A. Refer to Section 27 13 01, Communication Cables and Related Equipment.

2.04 ETHERNET CABLES

A. Refer to Section 27 13 01, Communication Cables and Related Equipment.

2.05 MULTIPLE CONDUCTOR CONTROL CABLE

A. Refer to Section 27 13 01, Communication Cables and Related Equipment.

2.06 THERMOCOUPLE CABLE

A. Provide thermocouple cable with solid conductors meeting requirements of ESDU 06018 and type-compatible with the thermocouple leads furnished with the motor or temperature sensor. Thermocouple cable shall have flame-retardant insulation, pair-assembled with left-hand lay, with flame-retardant outer jacket, with overall shield, and UL-listed as Type PLTC.

2.07 RADIO CABLE

A. Refer to Section 27 13 01, Communication Cables and Related Equipment.

2.08 PUBLIC ANNOUNCEMENT (PA) CABLE

A. Refer to Section 27 13 01, Communication Cables and Related Equipment.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Coordinate installation of communication circuit wires and cables with the requirements of Section 20 70 26, Common Materials and Methods for Electrical Systems, Section 20 50 13, Raceways for Facility Services, Section 26 05 24, Low Voltage Wires and Cables, and Section 20 70 13, Common Materials and Methods for Electronic Services.

B. Fiber optic cables for Train Control and Communication Systems shall be installed as follows:

1. Communication cables between Stations shall be installed in one of the five innerducts in the Communications section of the system wide raceway.

2. Train control cables between Train Control Rooms or Houses shall be installed in innerducts in the Train Control section of the systemwide raceway.

3. Lateral cables to Train Control Rooms or Houses shall be installed in separate innerducts.

4. Communication cables between BART facilities and train control cables from Train Control Rooms or Houses to wayside devices may be without innerducts in the systemwide raceway.

3.02 IDENTIFICATION

A. Identification of wires and cables shall be in accordance with Section 26 05 24, Low Voltage Wires and Cables.

B. Labeling: Identification tags or labels shall be provided for each cable. Markers, tags and labels shall use indelible ink or etching which will not fade in sunlight or in duct applications. Markers, tags, and labels shall not become brittle or deteriorate for 30 years. Label termination panels with cable number or pair identifier for cables in accordance with TIA-606 and as specified. The labeling format shall conform to the BART Districtwide cable labeling schema and a complete record shall be provided to the District with the final documentation. Each cable shall be identified with type of signal being carried and termination points.

3.03 TESTING

A. General: Testing shall be in accordance with Section 01 45 24, Testing Program Requirements.

B. For communication related cables, refer to Section 27 13 01, Communication Cables and Related Equipment.

END OF SECTION 20 70 23

SECTION 20 70 26

COMMON MATERIALS AND METHODS FOR ELECTRICAL SYSTEMS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Connectors and insulating tapes.

B. Switches.

C. Receptacles.

D. Cover plates.

E. Disconnecting devices.

F. Individual control relays.

G. Nameplates and labelling.

1.02 RELATED SECTIONS

A. Section 20 50 13, Raceways for Facility Services

B. Section 26 05 24, Low Voltage Wires and Cables

1.03 INTERFACE AND COORDINATION

A. Interface and coordinate the work of this Section with the other Sections and other Divisions of these Specifications, as required to provide a complete and operable electrical installation.

B. Interface and coordinate also with Division 20, Facility Services Sections, which require electrical equipment and services as part of the mechanical installation.

C. Interface and coordinate electrical services and work with the jurisdictional utility company and the District, as applicable.

D. Interface and coordinate with work completed or in progress or to be performed under other sections of these Specifications or by other contractors. Make indicated connections to previously completed work. Where future connections to or extensions of the work are indicated, provide safe and convenient provisions for such future connections and extensions.

1.04 MEASUREMENT AND PAYMENT

Separate measurement and payment will not be made for the Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the Bid Schedule of the Bid Form, or incidental to the Work of the Contract.

1.05 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM D1000 Standard Test Methods for Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical and Electronic Applications
2. ASTM D1518 Standard Test Method for Thermal Resistance of Battling Systems Using a Hot Plate
3. ASTM D3005 Standard Specification for Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape
4. ASTM D5034 Standard Test Method for Breaking Strength and Elongation of Textiles Fabrics (Grab Test)
5. ASTM D5035 Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method)

B. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE C37.30.1 IEEE Standard Requirements for AC High-Voltage Air Switches Rated Above 1000V

C. National Electrical Manufacturers Association (NEMA):

1. NEMA KS 1 Heavy Duty Enclosed and Dead-Front Switches (600 Volts Maximum)
2. NEMA WD 1 General Color Requirements for Wiring Devices
3. NEMA WC 70 Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy
4. NEMA WC 71 Nonshielded Cable Rated 2001-5000 Volts for Use in the Distribution of Electric Energy
5. NEMA WC 74 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy

D. National Fire Protection Association (NFPA):

1. NFPA 130 Standard for Fixed Guideway Transit and Passenger Rail Systems

E. Underwriters Laboratories Inc. (UL):

1. UL 20 Standard for Safety General-Use Snap Switches
2. UL 486A- 486B UL Standard for Safety Wire Connectors
3. UL 486C Standard for Safety Splicing Wire Connectors
4. UL 498 Standard for Safety Attachment Plugs and Receptacles
5. UL 508 Standard for Safety for Industrial Control Equipment
6. UL 514A Standard for Safety Metallic Outlet Boxes

F. American National Standards Institute (ANSI)

1.06 DESCRIPTION

A. The Contract Drawings show raceways, wiring, and electrical facilities diagrammatically and do not show offsets, fittings, and accessories that may be required because of obstructing structural features and architectural finishes, interfering pipelines, ducts, and facility services equipment. The Contractor shall be responsible for investigating all such conditions and for determining the need for routing electrical raceways around such obstructions and interferences. The Contractor shall provide all such additional fittings, appurtenances, and accessories as required for routing raceways and wiring around obstructions and interferences and for providing complete and operable electrical systems and installations.

1.07 REGULATORY REQUIREMENTS

A. In addition to the foregoing referenced standards, the regulatory requirements that govern electrical work of these Specifications include the following codes and regulations:

1. California Code of Regulations:
    a. Title 8, Industrial Relations, Division 1, Chapter 4, Subchapter 4, Construction Safety Orders
    b. Title 8, Industrial Relations, Division 1, Chapter 4, Subchapter 5, Electrical Safety Orders
    c. Title 19, Public Safety, Division 1, State Fire Marshal
    d. Title 24, Part 2, California Building Code
    e. Title 24, Part 3, California Electrical Code

f. Title 24, Part 6, California Energy Code

g. Title 24, Part 9, California Fire Code

2. General Orders, State of California, Public Utilities Commission

3. Institute of Electrical and Electronics Engineers, Inc. (IEEE):

a. IEEE C2 National Electrical Safety Code (NESC)

1.08 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures; Section 01 33 23, Shop Drawings, Product Data, and Samples; and Section 01 78 23, Operation and Maintenance Data for submittal requirements and procedures.

B. List of Materials: At least 30 Days before beginning the work of this Section, submit a list of materials and equipment proposed for use together with applicable standards. Provide the name of manufacturer, brand name, and catalog number of each item. Submit the list complete at one time, with items arranged and identified in numerical sequence by Specification Section and Article number.

C. Compliance with Applicable Standards:

1. Where equipment or materials are specified to conform to the standards of organizations such as ANSI, ASTM, IEEE, NEMA, and UL, submit evidence of such conformance for review and record purposes.

2. The label or listing of the specified agency will be acceptable evidence.

3. Instead of the label or listing, the Contractor may submit a written certificate from an approved, nationally recognized testing organization, adequately equipped and competent to perform such services, stating that the items have been tested and that the units conform to the specified standard.

4. Submit evidence of compliance to seismic safety requirements of the California Building Code and the California Electrical Code.

D. Factory Test and Inspection Certification:

1. Except as otherwise specified herein, where factory tests and inspections for materials and equipment for which tests and inspections specified in referenced documents are waived, provide certified copies of reports for tests performed on previously manufactured identical materials or equipment within the previous 12 months.

2. Accompany test reports by signed statements from the manufacturer certifying that the previously tested material or equipment is physically, mechanically, and electrically identical to that proposed for the project. Include wiring and control diagrams.

E. Shop Drawings: Submit Shop Drawings showing conduit layout and the exact location and arrangement of conduits stubbed into future equipment, cabinets, pull boxes and assigned spaces, conduit sleeves for future exposed conduits, and for fabricated work being furnished and installed under these Specifications. Submit such drawings before rough-in work, fabrication, and within ample time to prevent delays in the Work. Include electrical diagrams for equipment and equipment installation.

F. Field Test Reports: Submit certified field test reports of field tests, verifying compliance of equipment and systems with Specification requirements.

PART 2 – PRODUCTS

2.01 GENERAL

A. Furnish materials and equipment of design, sizes, and ratings as indicated.

B. Furnish materials and equipment bearing label or classification listing of a national recognized testing laboratory where UL standards exist and such product labeling or listing is available. Electrical materials shall comply with the California Electrical Code.

C. Methods of fabrication, assembly, and installation are optional unless otherwise indicated.

D. Provide products that are free from defects that may impair performance, durability, or appearance.

E. Materials manufactured for use as raceways (except PVC conduit), boxes, cabinets, equipment enclosures, and their surface finish material shall be capable of being subjected to temperatures up to 932 degrees Fahrenheit (500 degrees Celsius) for one hour and shall not support combustion as specified in NFPA 130.

2.02 CONNECTORS AND INSULATING TAPES

A. Splice and Terminal Connectors:

1. Provide termination fittings for use with the cable furnished, NEMA standard, and conforming to UL 486A-486B.

2. Termination and splice fittings for No. 10 AWG and smaller conductors shall be compression type. Wires to be connected shall be grouped together and fitted into an appropriately sized tin-plated copper sleeve. After compressing with an appropriate tool, the connector shall be covered with a nylon-insulating cap. Wire splices shall comply with UL 486C. Screw-on and spring pressure type connectors are prohibited.

3. Termination and splice fittings for No. 8 AWG and larger conductors shall be tool-applied compression connectors of material and design compatible with the conductors for which they are used.

4. Terminal connectors for conductors' size No. 4/0 and larger shall be long-barrel, double-compression type, and shall be furnished with two NEMA standard bolting holes in the pad.

5. Provide heat-shrinkable insulator for every compression type connector.

B. Insulating Material for Splices and Terminations:

1. Provide insulating material for splices and terminations of type accepted by the Engineer for the particular use, location and voltage.

2. Plastic electrical insulating tape for general use shall be vinyl plastic with rubber based pressure sensitive adhesive, and shall be pliable at temperature of minus 18 degrees Celsius to 105 degrees Celsius. When tested in accordance with ASTM D3005, the tape shall have the following minimum properties:

   a. Thickness: Seven mils

   b. Breaking Strength: Fifteen pounds per inch

   c. Elongation: Two hundred percent

   d. Dielectric Strength: Ten kV/mil

   e. Insulation Resistance (Direct method of electrolytic corrosion): Ten MΩ

3. Rubber electrical insulating tape for protective over-wrapping shall be silicone rubber with a silicone pressure-sensitive adhesive. When tested in accordance with ASTM D1000, the tape shall have the following minimum properties:

   a. Elongation: Five hundred and twenty-five percent

   b. Dielectric Strength: Thirteen kV

   c. Insulation Resistance (Indirect Method of Electrolytic Corrosion): Ten MΩ

4. Arc-proof tape shall be flexible, conformable organic fabric, coated one side with a flame-retardant flexible elastomer, self-extinguishing, with the following minimum properties:

   a. Thickness, ASTM D1000: 55 mils

   b. Tensile Strength, ASTM D5034: 50 pounds per inch

   c. Thermal Conductivity, ASTM D1518: 0.0478 Btu ($h/ft^2/^oF$)

   d. Electrical Arc Resistance: Withstand 200 A arc for 40 seconds

5. Mark each tape package to indicate shelf-life expiration date.

2.03 SWITCHES

A. Provide ac tumbler-toggle switches conforming to minimum requirements of UL 20 and the requirements herein specified, of specification grade and heavy-duty type. Switches mounted outdoors shall be weatherproof.

B. Provide switches that operate in any position and are fully enclosed with entire body and cover of molded phenolic, urea or melamine. Do not use fiber, paper, or similar insulating material for body or cover.

C. Equip switches with metal mounting yoke with plaster ears, insulated from the mechanism and fastened to the switch body by bolts, screws, rivets, or other substantial means that meet test requirements.

D. Provide a green-colored equipment grounding screw on the yoke.

E. Provide the section of the yoke normally intended to bear on the surface outside the box with a minimum over-all dimension of a quarter of an inch, measured at right angles to the longitudinal axis of the yoke.

F. Switch contacts shall be silver or silver alloys.

G. Switches shall be back or side wired with terminals of screw or combination screw-clamp type.

H. Terminal screws shall be No. 8 or larger, captive or terminal type.

I. Provide wiring terminals capable of receiving and holding wire sizes as follows:

SWITCH RATING	WIRE SIZE, AWG NO.
20 A	12
30 A	10

J. Switches for use on incandescent or fluorescent lighting circuits shall be fully rated 20 A at 120 V or 277 V.

K. Switches controlling straight resistance loads may be snap switches as specified herein, of the proper rating up to 30 A at 120 - 277 V.

L. Provide 120 - 277 V AC snap switches capable of withstanding tests as outlined in NEMA WD 1, Paragraphs WD 1-2.04, WD 1-2.05A, WD 1-2.05C, WD 1-2.05E2, WD 1-2.05F2, and WD 1-2.05G. If requested by the Engineer, submit evidence that the types of switches proposed have satisfactorily withstood these tests.

2.04 RECEPTACLES

A. Receptacle Standards: Connector and outlet receptacles shall conform with UL 498 and NEMA WD 1 for heavy-duty general use type.

B. Convenience-Outlet Receptacles:

1. Provide receptacles with fire-resistant non-absorptive hotmolded phenolic composition bodies and bases and with metal plaster ears integral with supporting member. Receptacles shall be flush type, except where otherwise indicated.

2. Wall receptacles shall be NEMA 20R configuration single or duplex receptacles as indicated.

3. Provide receptacles and plugs (caps) with light-colored terminal facilities for neutral connections, amber or brass-colored for phase conductor connections, and green-colored hexagonal machine screws for the equipment grounding conductor or connections.

4. Contacts of the receptacles, including the grounding contact, shall be double-grip bronze type with spring steel backup clips so that both sides of each male prong of the plug will be in firm contact.

5. Provide receptacles with self-grounding clip or mounting strap screws.

C. GFCI Receptacles: Ground fault circuit interrupter (GFCI) duplex receptacles shall be 120 V, 60 Hz, 20 A with built-in test, reset buttons, and ground fault tripped indication. They shall interrupt the circuit within one thirtieth second on a five-milliampere earth leakage current. They shall be designed for end of run installation or with provisions for feeding through to protect other outlets on the circuit. Maximum circuit capacity for the latter shall be 20 A. The receptacles shall be furnished with necessary wire connectors, clips, mounting screws, and instructions. Provide GFCI duplex receptacles conforming to California Electrical Code in public areas and trainways.

D. Clock Receptacles:

1. Provide receptacles for clocks, recessed so that male cap will be flush with the wall to permit the clock to cover the outlet.

2. Provide plates, including finishes, as specified for cover plates, adapted to the recessed receptacles and with substantial hooks to support the clocks.

3. Receptacles for surface-mounted clocks shall be connected to the building 120 V electrical system.

4. Where clock receptacles are indicated or specified, furnish the grounded type, and provide with a ground jumper.

2.05 COVER PLATES

A. Provide cover plates for each switch, receptacle, and special purpose outlet. Colors for the receptacles and cover plate shall be as follows:

1. Receptacles fed from Uninterruptible Power Supply (UPS): orange.

2. Receptacles fed from Standby Generator Bus: red.

3. Cover plates shall be white.

B. Provide multi-gang plates for multi-gang boxes.

C. Provide cover plates conforming to UL 514A.

D. Provide cover plates of brushed stainless steel in ancillary spaces, mechanical rooms, fan rooms, electrical closets, AC switchboard rooms, traction power substations, and unfinished areas.

E. For special purpose outlets commercially produced using special material, configuration and size, provide plates of brushed stainless steel and of a design for the particular application.

F. Provide stainless steel cover plates of 0.040 inch thickness for flush devices.

G. Provide cover plates in public areas of die cast copper free aluminum, UL listed for wet locations and self-closing spring door.

2.06 DISCONNECTING DEVICES

A. Safety Switch Type Disconnecting Devices: Provide safety switch disconnecting devices, enclosed, conforming to IEEE C37.30.1.

B. Heavy-duty Safety Switches (600 V AC):

1. Provide heavy-duty safety switches having electrical characteristics, ratings, and accessories as indicated.

2. Provide switches with NEMA 12 industrial duty enclosures, with nameplates conforming to the requirements described elsewhere in this section. Nameplates shall be mounted on the enclosure front, and shall contain identification of switch type, catalog number, and HP ratings.

3. Provide handle with visible blades; reinforced fuse clips; non-teasible, positive, quick-make quick-break mechanism; and padlockable in the OFF and ON positions.

4. Provide switches meeting NEMA KS 1 requirements.

2.07 INDIVIDUAL CONTROL RELAYS

A. Control relays shall have convertible contacts rated a minimum of 10 A, 600 V. Verify coil voltage, and number and type of contacts. Furnish in NEMA 1 enclosures.

2.08 NAMEPLATES AND LABELLING

A. Provide nameplates for identification of switchboard assemblies, motor control centers, equipment, and devices with the following characteristics:

1. Nameplates for indoor installations shall be a sixteenth of an inch thick lamicoid, with beveled edges, black background, and white letters. Nameplates shall be mounted using stainless steel rivets, or attached using permanent adhesive.

2. Nameplates for outdoor installations shall be metallic sheet with enamel painted white letters on black background. Nameplates shall be mounted using stainless rivets.

3. Nameplate sizes:

   a. Switchboard and motor control center assemblies nameplates shall be four-inch wide with two and a half inch lettering.

   b. Individual cabinet and major equipment nameplates shall be two and a half inches wide with half an inch lettering.

   c. Nameplates for switches, relays, and other devices mounted inside cabinets shall be three fourths-inch wide with three sixteenths-inch lettering.

4. Nameplate legends shall be submitted for District approval.

B. Labelling shall be provided for electrical equipment including, but not limited to: panels (inside and outside), junction boxes, conduits, lighting fixtures, lighting poles, and wiring. Format and details of the labelling shall be approved prior to installation by the Engineer.

PART 3 – EXECUTION

3.01 INSTALLATION REQUIREMENTS

A. Install electrical materials, equipment, appurtenances, and accessories in locations as indicated, rigid and secure, plumb and level, and in alignment with related and adjoining work to provide a complete and operable system. Do not weld electrical materials for attachment or support.

B. Provide anchor bolts and anchorage items as required, and field check to ensure proper alignment and location. Provide templates, layout drawings, and supervision at the jobsite to ensure correct placing of anchorage items in concrete. Check embedded items for correctness of location and detail before concrete is placed.

C. Install supporting members, fastenings, framing, hangers, bracing, brackets, straps, bolts, and angles as required to set and connect the work rigidly. Conform with the seismic restraint requirements of the California Building Code and the California Electrical Code.

D. Control erection tolerance requirements so as to not impair the strength, safety, serviceability, or appearance of the installations. Determine exact locations of conduit. Route conduit parallel to building lines unless otherwise indicated.

E. The trade size, type, and general routing and location of conduits, raceways, and boxes shall be as indicated or specified.

F. Install exposed conduit so as to avoid conflicts with other work. Install horizontal raceways close to the ceiling or ceiling beams, and above water or other piping wherever possible.

G. Install individual conductors and multiple-conductor sheathed cables in conduits, raceways, cable trays, ducts, and trenches as indicated to complete the wiring systems.

H. Install switches, receptacles, special purpose outlets, and cover plates complete in a neat manner in accordance with the California Electrical Code and local electrical codes. Plug unused openings in boxes, cabinets, and equipment.

I. Use of explosive fasteners is prohibited.

J. All electrical equipment, panels, telephone, and fire alarm panels shall be sealed against dust, whenever dusty conditions are present inside the rooms or outside, during the construction period.

3.02 CONDUIT AND FITTINGS

A. Provide as indicated and required in accordance with the requirements of Section 20 50 13, Raceways for Facility Services.

3.03 EQUIPMENT, APPURTENANCES, AND INSTALLATION ACCESSORIES

A. Provide conduit hangers and inserts, pull cords, outlet boxes, junction and pull boxes, metal and plastic cable tray systems, and underfloor ductwork as indicated and required in accordance with the requirements of Section 20 50 13, Raceways for Facility Services.

3.04 WIRING

A. Wiring Requirements:

1. Provide wiring as indicated and required in accordance with the requirements of Section 26 05 24, Low Voltage Wires and Cables.

2. Furnish wires and cables to the site in unbroken standard coils or reels to which shall be attached a tag bearing the manufacturer's name, trade name of the wire, and the UL label for 600 V wire and cable.

3. Provide wiring complete as indicated. Provide ample slack wire for motor loops, service connections, and extensions. In outlet or junction boxes provided for installation of equipment by others, tape ends of wires and install blank covers.

4. Measure insulation resistance of the wiring system before connection to terminal blocks, motors, switchboards, motor control centers, transformers, panelboards, and control cabinets.

5. Do not bend cables during installation, either permanently or temporarily, to radii less than 12 times the outer diameters, except where conditions make the specified radius impracticable and shorter radii are permitted by the California Electrical Code and NEMA WC 70, Appendix F; NEMA WC 71, Appendix F; and NEMA WC 74, Appendix I.

6. Secure and neatly bundle with nylon straps cables inside panelboards, control cabinets, switchboards, motor control centers, terminal cabinets, junction boxes, and pull boxes.

7. Identify wiring as specified in Section 26 05 24, Low Voltage Wires and Cables.

B. Cable Supports: Install cable supports for vertical feeders in accordance with the California Electrical Code.

C. Splices and Terminations:

1. Make wire and cable splices only in outlet, junction or pull boxes, or in equipment cabinets. Splices in conduit or raceway will not be permitted. Make splices by means of compression type connectors, and cover with tape to an insulation level equal to that of the cable.

2. Use positive type connector installation tools as recommended by the manufacturer.

3. Mechanical hand tools, with dies for each conductor size as recommended by the manufacturer, may be used on conductor sizes smaller than or equal to No. 6 AWG.

4. For conductor sizes larger than No. 6 AWG, use hydraulic tools with hexagonal or circumferential installing dies for each conductor size, as recommended by the manufacturer.

5. For inspection purposes, clearly mark die numbers on the installed connectors.

6. Before installation, apply anticorrosion electrical joint compound to conductors and terminal bolting pads.

7. Wire and cable shall be continuous from power source to equipment. Where splices are required, they shall be made only in approved fittings or junction boxes and shall be subject to approval by the Engineer. Follow manufacturer's instructions in splicing wire and cable.

8. Fixture Wire: Make splices in lighting circuits with insulated crimp-type connectors.

9. Control Cables: Each wire held with screw-type terminals shall be terminated using insulated sleeve (nylon), ring tongue-type or locking spade-type, crimp-on lugs. For wires sizes below No. 10 AWG terminating into tubular clamp-type terminals, the conductor shall be stripped and terminated bare.

10. Heat-shrinkable insulator shall be centered over the compression sleeve of the connector and shrunk tight to cover the connector sleeve.

3.05 WIRING DEVICES

A. Locate switches 4 feet above finished floor and general-purpose duplex convenience receptacles 15 inches above finished floor, except as otherwise indicated.

B. Attach receptacles rigidly to outlet boxes by means of two stainless steel screws.

C. For exterior and damp locations, surface or embedded, mount receptacles in watertight cast metal outlet boxes with threaded hubs or bosses and equipped with gasketed spring cover.

D. Provide NEMA 3R locking type male plugs for equipment permanently connected to exterior GFCI type receptacles and subject to spray or hose cleaning.

END OF SECTION 20 70 26

SECTION 20 72 25

FACTORY AND FIELD TESTING

Part 1 – GENERAL

1.01 SECTION INCLUDES

A. Requirements for factory and field testing for equipment, devices and systems as specified in the following Contract Specifications Divisions:

1. Division 14 – Conveying Equipment.
2. Division 21 – Fire Suppression.
3. Division 22 – Plumbing.
4. Division 23 – Heating, Ventilating and Air Conditioning.
5. Division 26 – Electrical.
6. Division 27 – Communications.
7. Division 28 – Electronic Safety and Security.
8. Division 34 – Transportation.

1.02 RELATED SECTIONS

A. Section 01 32 16, Project Progress Schedules

B. Section 01 33 00, Submittal Procedures

C. Section 01 43 00, Quality Assurance

D. Section 01 45 00, Quality Control

E. Section 01 52 00, Construction Facilities

F. Section 20 80 00, Systems Integration Testing

G. Section 34 21 05, Prefabricated DC and AC Houses

H. Section 34 21 80, TP System Field Acceptance Testing

1.03 GENERAL REQUIREMENTS

A. Test requirements for individual items of equipment, devices, or systems are covered within the Contract Specifications of those components or systems; these include Contract Specifications Divisions 14, 21, 22, 23, 26, 27, 28, 33, or 34.

Systems integration testing is covered in Contract Specifications Section 20 80 00, Systems Integration Testing.

B. Develop test procedures, perform tests, and document test results, as specified herein. The Contractor shall have an approved test procedure before starting the applicable tests.

C. Quality assurance and control are specified in Contract Specifications Section 01 43 00, Quality Assurance and Section 01 45 00, Quality Control.

D. Prepare all submittals in accordance with Contract Specifications Section 01 33 00, Submittal Procedures.

1.04 TEST RESPONSIBILITY

A. Perform all factory and field tests that are specified as the Contractor's responsibility. Provided support for District testing as specified; however, the Contractor will not be responsible for any other aspect of District testing. Tests shall be performed by the Contractor, the equipment manufacturer, or an accredited testing laboratory as approved by the District. Although District personnel will witness Contractor testing, the Contractor shall be responsible for planning, scheduling, and performing the tests.

B. All factory and field-testing shall be conducted under the direction of the Contractor's System's Integration Manager. Individual subcontractor test directors shall report directly to the System's Integration Manager.

C. Furnish all test instruments and any other equipment and materials necessary to perform the tests.

D. Acceptance of the structures, facilities, and equipment provided under the Contract is contingent upon successful compliance with inspection and test requirements. These tests shall demonstrate the performance of the equipment at various points in the design, manufacturing, and installation process.

E. The Contractor shall be held fully responsible for the repair or replacement of equipment damaged as a result of tests and shall bear all associated costs.

1.05 TEST PLAN AND SCHEDULE

A. Within six months of NTP, submit a schedule of all factory and field test types that are proposed for all tests as specified in Contract Specifications Divisions 14, 21, 22, 23, 26, 27, 28, 33, or 34 and Contract Specifications Section 20 80 00, Systems Integration Testing. Utilize the schedule format shown in the attachment to this Contract Specifications Section.

B. For each system or subsystem, prepare and submit eight copies of a test plan to the District Representative for approval no later than the time of the system level design review for the applicable system or subsystem.

C. The test plan shall list each test procedure that will be submitted by the Contractor to demonstrate compliance with the requirements of this Contract. The test plan shall contain a schedule with the date, location and duration for all tests, based on site availability forecasts and any sequencing requirements. The test plan shall also include:

1. An index describing each test with its procedure number and objectives.
2. A list of applicable pre-requisites for each test.
3. Test program personnel organization and responsibilities of each organization level.
4. Test reporting methodology, including instructions for recording pertinent test conditions, identifying, evaluating, and correcting causes of problems or failures.
5. Sample general test sheets and instructions for their use.
6. Description of procedures for preparing and submitting test data sheets.
7. Identification, where applicable, of primary test agency if other than the Contractor.
8. General provisions for re-test as a result of either test failure or modification of equipment after test.
9. Description of method used to schedule each test.
10. Test plan revision procedure and controls.

D. Testing Schedule: Submit a test schedule for District approval. The schedule shall include all specified tests for individual equipment, systems, subsystems, and systems integration testing.

1. The schedule shall be reflected in the Milestone Summary and Detailed Project Schedules as defined in Contract Specifications Section 01 32 16, Project Progress Schedules.
2. Identify each test as follows:
    a. Category (i.e. equipment, system, or integration test).
    b. Number and title of test.
    c. Constraining activities affecting test.
    d. Location of test.
    e. Projected duration of test.
    f. Sequencing of tests, with emphasis on prerequisites.

1.06 TEST PROCEDURES

A. Develop a written test procedure for each test identified in the test plan. Submit each test procedure to the District Representative for approval at least 60 Days before the start of the respective test. The test procedure shall include:

1. Test title and ID number.

2. Statement, including diagrams where appropriate, identifying the equipment or systems to be tested, test objectives, and scope.

3. Personnel required.

4. Applicable industry standards.

5. List of equipment required to perform the test. Test instruments shall be listed including manufacturer, model, type, and serial number.

6. List of equipment, services, or facilities required from areas outside of the Contractor's authority, including identification of required District-furnished material, personnel, equipment, and facilities access.

7. List of prerequisite tests.

8. Description of the required test setup, including, but not limited to, diagrams illustrating test equipment connections and identifying test points.

9. Step-by-step instructions for performing the test and identifying the points at which data will be recorded.

10. Test constraints.

11. Pass/fail criteria.

12. Limits for acceptable data and an explanation of any special data reduction methods.

13. Specific provisions for re-test as a result of either test failure or modification of equipment after test; and

14. Test Data Sheets. Test data sheets shall identify the test, and shall be designed to include spaces to record test data, test date, and signatures of individuals performing and witnessing the tests. Data sheets shall be arranged in tabular form where practical. For each test procedure, provide general and specific data sheets.

    a. General Test Data Sheets: General or generic test data sheets shall provide a template, or general layout, for all tests in a particular test category. General test data sheets can be prepared to apply in more than one test category. General data sheets shall include test identification, date or revision number, and spaces for check-off, discrepancies, and verification of the test's completion. Where applicable, general test data sheets shall include drawing

numbers, test equipment and their respective model numbers, references to the applicable procedure number, allowable limits for certain entries, and corrective actions required.

b. Site-Specific Test Data Sheets: Site-specific test data sheets shall contain all the information for each test category and each test condition pre-filled out. Test data sheets incorporating site-specific information shall be filled out and submitted to the District 10 Days prior to conducting test. Data entries shall be referenced to the applicable procedure, and allowable limits for each entry shall be indicated on the data sheets.

1.07 TEST NOTIFICATION AND WITNESSING

A. Notify the District Representative and all participating parties 30 Days before the scheduled start of tests. The District reserves the right to witness all tests or appoint an independent agency as a test witness representative. The witness(es) will be present on a non-interfering and non-participatory basis. All witnessing parties shall sign the test reports; however, their signature(s) shall not constitute a guarantee or endorsement of the tests or results.

1.08 TEST SUPPORT DOCUMENTATION

A. All relevant Contractor-prepared drawings and submittals shall be available for reference during the conduct of each test.

1.09 TEST EQUIPMENT/INSTRUMENT CERTIFICATION

A. Test equipment/instruments shall be calibrated and accuracy certified within 180 days prior to use. Submit calibration certification with the relevant test reports.

1.10 TEST REPORTS

A. General: Prepared and submit test reports for review and approval by the District Representative no later than 10 Days after completion of the respective test. As a minimum, the test report shall contain test data sheets, test commentary and a conclusion statement.

B. Test Data Sheets: Test reports shall include completed test data sheets prepared in accordance with Article 1.06A.14 herein. Completed test data sheets shall contain all site-specific information, test results, and appropriate signatures.

C. Test Commentary: Prepare a brief commentary on the test. The commentary shall compare the test results and fail/pass criteria, where applicable. In case of test failure, the commentary shall provide an analysis of the test, probable reasons for the failure and remedial measures the Contractor intends to undertake. If failure is corrected during the test, the commentary shall include the corrective action taken.

D. Conclusion: Provide a concluding statement assessing the success or failure of the test.

1.11 REJECTION AND RETESTING

A. All equipment shall be examined and inspected thoroughly immediately after the test has been completed.

B. Failure of equipment to meet the performance requirements, or damage sustained during the test, shall be sufficient grounds for rejection of equipment. Equipment failing to pass the test shall have deficiencies corrected by modifications, if necessary, and be retested without impacting the project schedule unless otherwise approved in writing by the District.

C. If the modifications or changes affect any drawings, diagrams, software, or other documents previously submitted to and accepted by the District Representative, such drawings, diagrams, or software shall be revised showing the proposed changes and submitted to the District Representative for approval.

D. The cost of any rework of a unit or system, or the manufacture of a new unit or system, including retesting and witnessing by the District, shall be borne by the Contractor.

Part 2 – PRODUCTS

Not Used

Part 3 – EXECUTION

3.01 FACTORY TESTS

A. Factory tests shall verify equipment compliance with performance, reliability, and safety requirements and applicable standards and codes. Factory tests shall begin only after the following requirements have been met:

1. The design of the equipment has been approved by the District Representative.

2. The specific test procedures to be used for factory testing have been approved by the District Representative.

3. Current, up-to-date copies of all contract drawings pertaining to the system or equipment being tested shall be made available to all test attendees.

B. Factory tests, classified into design, production and system tests, shall be performed as required to satisfy the following requirements:

1. Design tests shall be performed on the first assembled equipment or system component of a given type. The purpose of a design test is to demonstrate compliance to the specified functional and performance requirements of these Specifications, or applicable industry standards.

2. Production tests shall be performed on every completely assembled item of equipment, system component or subsystem to verify the quality and correctness of the manufacturing and assembly processes.

3. System tests shall be performed as specified in the factory test requirements for individual items of equipment, devices, or systems within the Contract Specifications Sections of those components or systems.

C. For uniform simple components manufactured in large quantity, such as contact rail sections, coverboard sections, and insulators, factory tests shall be conducted on batch samples. The batch size and sample selection procedure shall be in accordance with the requirements of the Contract Specifications, or if not specified, shall be submitted for approval by the District Representative.

D. No equipment shall be shipped to the field until the appropriate factory test reports have been submitted and approved by the District Representative.7

3.02 FIELD TESTS

A. Field tests shall verify the quality and workmanship of the installation, calibrate and adjust control and protective devices, demonstrate the proper functioning of the various systems and interfaces (including the interface with the existing BART system), and prove compliance of all equipment to the performance, reliability, and maintainability requirements as defined in these Specifications.

B. Perform the required field tests in accordance with approved test procedures and schedule, except that the District reserves the right to direct the Contractor to change the test sequence or the hours in order to accommodate the District's revenue service and other requirements. This shall be done at no additional cost to the District.

C. Field tests, classified into installation verification, functional, performance and systems integration tests, shall be performed prior to acceptance of the work.

1. Installation verification tests shall be performed upon completion of the installation of the equipment or system in question. Depending on the nature of the equipment or system, a variety of approaches may be required to verify that the installation has been completed in accordance with the Contractor’s design and the equipment manufacturers’ recommendations:

   a. Installation verification tests for standalone systems such as UPSs, HVAC units, and fire alarm control panels shall be conducted in accordance with the manufacturer’s published recommendations.

   b. Installation verification tests for electrical and communication systems that involve device and inter-cabinet wiring shall be based on Contractor-prepared interconnection diagrams which shall be marked-up to indicate that each wire is correctly terminated and continuity has been verified.

2. Functional tests shall be performed upon completion of the associated installation verification test. Functional tests shall be performed as specified in

the field test requirements for individual items of equipment, devices, or systems within the Contract Specifications Sections of those components or systems.

3. Performance tests, where specified in the related specification section, shall be performed upon completion and acceptance of the associated functional tests, and shall be used to confirm required performance characteristics and capabilities of the tested equipment.

4. System integration tests shall be performed as specified in Contract Specifications Section 20 80 00, Systems Integration Testing.

ATTACHMENT 1 – TO SECTION 20 72 25

FACTORY AND FIELD TEST OF SUBMITTAL LIST (SAMPLE)

Division	Section and System	Factory Tests			Field Tests		
		Design	Production	System	Installation Verification	Functional / Performance Test	System Integration Test
14 Conveying Equipment	Section 14 24 00, Hydraulic Elevators	No	Yes	No	Yes	Yes	No
	Section 14 31 00, Escalators	No	Yes	No	Yes	Yes	Yes

END OF SECTION 20 72 25

SECTION 20 80 00

SYSTEMS INTEGRATION TESTING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Specifications for all phases of systems integration testing.

1.02 RELATED SECTIONS

A. Section 01 20 00, Price and Payment Procedures

B. Section 01 33 00, Submittal Procedures

C. Section 01 35 14, Operating System Interface

D. Section 01 43 00, Quality Assurance and Quality Control

E. Section 01 52 00, Construction Facilities

F. Section 20 72 25, Factory and Field Testing Requirements

G. Section 27 21 00, Unified Optical Network

H. Section 34 21 80, Traction Power System Field Acceptance Testing

1.03 MEASUREMENT AND PAYMENT

A. The work specified in this Section will be paid for under the applicable Bid Items based on the locations where work is performed, as identified in the Form – Description of Bid Items, in accordance with Contract Specifications Section 01 20 00, Price and Payment Procedures.

1.04 ABBREVIATIONS

AC	-	Alternating Current
AFC	-	Automatic Fare Collection
ATC	-	Automatic Train Control
ATO	-	Automatic Train Operations
BARTnet	-	BART Communications Network
CPUC	-	California Public Utilities Commission
DC	-	Direct Current
EBP	-	Emergency Backup Panel

ET	-	Emergency Telephone
ETP	-	Emergency Trip Panel
ETS	-	Emergency Trip Station
ETTS	-	Emergency/Transfer Trip System
FACP	-	Fire Alarm Control Panel
FT	-	Fire Telephone
ICS	-	Integrated Control System
I/O	-	Input/Output
IP	-	Internet Protocol
IPR	-	Integrated Protection Relay
IPPBX	-	Internet Protocol Private Branch Exchange
IRAT	-	Integrated Remote ATO Terminal
LAN	-	Local Area Network
LCD	-	Liquid Crystal Display
LMA	-	Lake Merritt Administration
MPR	-	Multifunction Protection Relay
OCC	-	Operations Control Center
PSTN	-	Public Switched Telephone Network
PA	-	Public Address
PIDS	-	Portal Intrusion Detection System
PLC	-	Programmable Logic Controller
PTS	-	Platform Trip Station
PTC	-	Project Test Center
QC	-	Quality Control
SAB	-	Station Agent Booth
SCADA	-	Supervisory Control and Data Acquisition
SFO	-	San Francisco
SRST	-	Survivable Remote Site Telephony
SSWP	-	Site-Specific Work Permit

TCH	-	Train Control House
TCR	-	Train Control Room
UON	-	Unified Optical Network
UPS	-	Uninterruptible Power System
VCP	-	Ventilation Control Panel
VOIP	-	Voice over IP

1.05 PROJECT TEST CENTER (IF APPLICABLE)

A. Provide and install a temporary Project Test Center (PTC) in the vicinity of a train control room (TCR) on the project alignment to facilitate systems integration testing and minimize interference with the Operations Control Center (OCC) and revenue operations.

B. House the PTC in a double-wide construction trailer as specified in Contract Specifications Section 01 52 00, Construction Facilities. Divide the trailer into two main areas; a test area and a conference room. Provide sufficient tables and chairs to accommodate 20 people in the conference room. In the test area, provide and/or install the following equipment:

1. Provide equipment tables, chairs, filing cabinets, convenience outlets and additional lighting as required.

2. Provide essential power for all specified workstations and LMA headend equipment from the uninterruptible power system (UPS) in the adjacent TCR.

3. Install and connect all Central equipment being furnished by the project.

4. Provide and/or install the following workstations as applicable for the project:

    a. Two District-furnished, ICS workstations.

    b. Four temporary Contractor-furnished workstations with 22 inch LCD screens, including two for EBP and two for IRAT functions. The application software for these workstations is provided by BART and shall be used by the Contractor to perform end-to-end system testing of the communications and train control systems respectively. Application software testing will be performed by BART with Contractor support as required.

    c. One video workstation (relocated from the TCR).

    d. One temporary, Contractor-furnished workstation equipped with manufacturer-furnished software for the remote monitoring of diagnostic information in multifunction and integrated protection relays (MPRs and IPRs) associated with AC and DC traction power circuit breakers, AC substation circuit breakers and ventilation fan starters if applicable.

5. Provide a minimum of two connections to the public switched telephone network (PSTN).

6. Install IPPBX, ET and FT handsets as needed.

7. Provide portable radios to communicate with the above and below-ground radio system as applicable.

C. Following the installation of all equipment in the PTC, test all equipment for proper connectivity and operation prior to the commencement of any other systems integration testing.

D. Upon completion of all systems integration testing, ship all communications equipment to LMA where the equipment will be installed by the District with Contractor support as needed. The PTC shall then be demobilized.

1.06 DESCRIPTION OF SYSTEMS INTEGRATION TESTING

A. The term “system(s)” as used in this Contract Specifications Section shall mean individual equipment or devices or groups of equipment or devices forming a subsystem or system as specified in Contract Specifications Divisions 14 through 34.

B. Systems integration testing shall begin only after the successful completion of applicable installation verification and functional system testing requirements for a given system or section of the Work. The requirements for equipment and systems installation verification and functional testing shall be as defined in Contract Specifications Section 20 72 25, Factory and Field Testing Requirements and the field testing requirements as defined in each system or equipment specification section.

C. Systems integration testing shall be performed by the Contractor and/or BART, as specified herein, to verify the operation and performance of all systems provided as part of this contract, systems provided by the District, and the existing BART system, as one complete and integrated work. Testing shall be performed in three phases as follows:

1. Inter-system, intra-facility functional testing will, in most cases, be performed locally rather than from a centralized location. Examples include interfaces between:

   a. PA, fire alarm and SCADA systems at the project station(s).

   b. Video surveillance, PA and IPPBX systems at the project station(s).

   c. Circuit breaker multifunction relays (MPRs) and network switches at various locations.

2. Inter-facility, systems integration testing will be performed at the PTC and includes the following systems as described in Part 3:

   a. SCADA system end-to-end testing.

b. Communications systems end-to-end testing.

c. 34.5 KV subtransmission system.

d. Auxiliary substations.

e. Ventilation system (if applicable).

f. Traction power system.

g. Automatic train control testing.

3. Final configuration testing at the OCC: Following the completion of all systems integration testing at the PTC, the LMA headend equipment shall be transferred to Central for installation by the District. Upon completion of the installation, each system shall be tested to verify correct operation with existing equipment at Central. This work will be performed by the District with Contractor support. The District will also conduct testing of all OCC workstations and the “big board” display prior to beginning up to 12 weeks of pre-revenue operations to familiarize BART personnel with the new Extension.

D. Perform systems integration testing with all systems configured as they would be under revenue service with the exception of the LMA equipment located in the PTC during phase 2 of systems integration testing. Systems integration testing shall include all interfaces between systems provided as part of this Contract and the existing BART system.

E. Adopt and implement an approved safety program during systems integration testing. In addition:

1. Coordinate which sections of the traction power system will be energized.

2. Grant work access to non-energized areas for its own forces and the District.

3. Operate a District-approved red tag procedure in accordance with Contract Specifications Section 01 35 14, Operating System Interface.

1.07 TEST RESPONSIBILITIES OF THE CONTRACTOR

A. Perform all system integration tests that are specified as the Contractor’s responsibility. Provide support for District testing as specified. However, the Contractor will not be responsible for any other aspect of District testing.

B. Conduct all system integration testing under the direction of the Contractor’s quality control (QC) group. Individual subcontractor test directors shall report directly to the Contractor’s QC group.

C. Comply with all quality assurance and control requirements as specified in Contract Specifications Section 01 43 00, Quality Assurance.

D. Furnish all test instruments and any other equipment and materials necessary to perform the tests.

E. Assume full responsibility for the repair or replacement of any equipment damaged as a result of tests and bear all associated costs.

1.08 TEST RESPONSIBILITIES OF THE DISTRICT

A. During systems integration testing, the District will perform the following tasks:

1. Review and approve test plans, procedures and results.

2. Monitor and witness tests performed by the Contractor.

3. Conduct tests that are the responsibility of the District. Contractor support shall be provided as needed during tests performed by the District. An allowance will be set-aside to cover the cost of testing support to the District.

4. Furnish revenue vehicles according to the following availability schedule:

   a. Up to 10 cars, as required, forming any combination of train consists from one 10-car train to multiple trains with the minimum train consist being three cars in length.

   b. Any additional cars will be furnished on Sundays from 0130 hours to 0700 hours.

5. Furnish District staff as required to perform the following tasks:

   a. Operate vehicles.

   b. Protect test trains operating in an assigned test area.

   c. PTC and OCC control operations.

   d. Any other District responsibility.

6. Coordinate attendance of witnesses from other agencies including the CPUC, Fire Marshals, and other governing and regulating agencies.

1.09 SYSTEMS INTEGRATION TEST PLANS, PROCEDURES, DATA SHEETS AND RESULTS

A. Except as modified herein, submittals requirements and procedures shall be as specified in Contract Specifications Section 01 33 00, Submittal Procedures.

B. The systems integration test program plan, schedule, procedures, data sheets and results shall be prepared in accordance with Contract Specifications Section 20 72 25, Factory and Field Testing Requirements.

C. Submittals specified herein will be reviewed by the District and returned to the Contractor within 30 days after receipt of the submittals. Prepare documents and schedule their submittals such that documents should have been approved by the District according to the following schedule:

1. Systems integration test program plan - 240 days prior to start of any systems integration test.

2. Systems integration test schedule - 180 days prior to start of any systems integration test.

3. Systems integration test procedures and generic data sheets - 90 days prior to start of applicable test.

4. Site-specific data sheets - 45 days prior to start of applicable test.

PART 2 – PRODUCTS

Not used

PART 3 – EXECUTION

3.01 TESTING GENERAL REQUIREMENTS

A. Use of District Facilities and Equipment: Access to District facilities or use of District operating equipment (e.g., in-service equipment rooms or Central Control facilities) shall be identified in the applicable test procedures and coordinated through the District Representative. Access and the availability of District facilities and equipment, when required, will be provided only upon District approval of a site-specific work permit (SSWP), as defined in Contract Specifications Section 01 35 14, Operating System Interface.

B. PTC Test Manager and Directors: Assign a Test Director under the direction of the QC Manager for each systems integration test. The Test Director shall be responsible for the overall performance and safety of the test.

C. Perform the start-up, operation, and shutdown activities of each test in accordance with the District-approved Contractor’s red tag procedures.

D. Utility charges for electrical power demand and energy during systems integration testing will be the responsibility of the Contractor, per Contract Specifications Section 01 20 00, Price and Payment Procedures, Allowance for Utility Services.

E. Where actual fault or abnormal conditions cannot be produced to operate protective relays or other devices, tests shall be performed by applying a short across the contacts at the device locations, or by simulating the applicable inputs to the devices.

F. Procedure for Conducting Tests: During systems integration testing, test personnel will be stationed at the PTC and at field devices/equipment as appropriate for the test being conducted. Systems integration testing may require up to four individuals (BART and/or Contractor personnel) as follows:

1. Two people will be stationed at the PTC (Test Director and one assistant) and they will direct the testing and monitor the workstations to verify that status and alarm inputs are correctly displayed on the appropriate displays and that appropriate commands are correctly executed.

2. As each step in a test procedure is successfully completed, the test director and a witness at the PTC will initial the test. If a District representative is present during a Contractor-conducted test, he/she shall initial the test as the “witness”. If a problem is detected, make a notation in the comments column and record the problem on the punch list. Repeat the test when the problem is corrected and before submitting the test results to the District for approval. When testing is completed and all punch list items have been corrected, the appropriate parties shall sign the test report cover sheet.

G. A typical systems integration test related to inter-system functional testing from the SFO Extension Project is given in Attachment A.

3.02 SCADA SYSTEM END-TO-END TESTING

A. End-to-end tests shall be performed using the EBP workstations to verify the correct operation of all SCADA I/O points and associated indications on the workstation displays. Because BART is configuring the EBP workstation display software, testing shall be a shared responsibility with each party responsible for correcting problems associated with their work.

B. BART may choose to concurrently test the ICS workstation SCADA I/O point displays.

3.03 COMMUNICATIONS SYSTEMS END-TO-END TESTING

A. Communications systems that interface to LMA headend equipment installed in the PTC shall be tested end-to-end after the BARTnet and Security networks on the UON have been successfully tested. These systems include all telephone systems, the station PA system, the video surveillance system, and the access control system.

B. BART will furnish the headend access control server software to the Contractor. Install this software on one of the LMA video servers to perform end-to-end testing of the access control system.

C. Testing of the administrative network devices shall be deferred until the LMA equipment is installed at Central. End-to-end testing with the existing access control server will be performed by the District with Contractor field support.

3.04 34.5 KV SUBTRANSMISSION SYSTEM

A. Energization Test: The energization test shall be performed only after successful completion of the following:

1. Field installation test of the 34.5 kV cable system.

2. Energization of the applicable high voltage substation.

3. Verification that the applicable sectionalizing station and traction power substations for the traction power system are ready for energization.

4. Verification that applicable auxiliary substations for the line electrical power distribution system are ready for energization.

B. The test shall be performed to verify the integrity of the 34.5 kV cable system under energized conditions.

3.05 AUXILIARY SUBSTATIONS

A. General: The following tests shall include:

1. End-to-End Tests: Verify that all substation remote monitoring and control points that are accessible from the ICS and EBP workstations at the PTC function correctly. In addition, verify the correct access and receipt of diagnostic data from the AC breaker MPR relays. The manufacturer's MPR monitoring software shall be loaded on to a PTC workstation to perform this test.

2. Energization Tests: The energization test shall be performed only after successful completion of the following:

   a. Field testing and energization of the applicable switching station and section of 34.5 kV cable system supplying power to the auxiliary substations (Applicable to portions of the auxiliary substations receiving power from the traction power 34.5 kV system).

   b. Testing and energization of the electric utility feeder line, and verification by the electric utility that the applicable auxiliary substation is ready for energization. (Applicable to auxiliary substations or portions thereof receiving power from the electric utility).

   c. Field tests of the auxiliary substation equipment.

   d. Remote control and indication tests for the auxiliary substations as specified above.

3. Perform the energization test to verify the integrity of each item of equipment in the power distribution system under energized conditions.

4. The energization test shall cover all equipment, devices, and electrical loads in the 34.5 kV to 480 V range and other low voltage systems in the power distribution system including those in auxiliary substations, other wayside facilities and on the trackways.

3.06 TRACTION POWER SYSTEM

A. General: Perform the following system integration tests after completion of the system-specific and equipment-specific field tests of the traction power facilities,

34.5 kV sub-transmission and 1000 VDC distribution systems, contact rail system, and related communications systems.

B. Remote Monitoring and Control Point Testing: Verify the proper operation of all monitoring and control points between each traction power facility's CO2 panel and the ICS and EBP workstations at the PTC. In addition, verify the correct access and receipt of diagnostic data from each AC breaker integrated protection relay (IPR) and each DC breaker MPR. The manufacturer's MPR and IPR monitoring software shall be loaded on a PTC workstation to perform this test.

C. Energization Test:

1. Verify the integrity and proper operation of all equipment in the traction power system under energized conditions. Perform this test shall after the successful completion of the field tests on the standalone systems involved, and the remote control and indication test specified above.

2. Perform the energization test on the entire traction power system including the AC system comprising of the 34.5 kV sub-transmission feeders and sectionalizing stations; and the 1000 VDC system comprising the traction power substations, gap breaker stations and contact rail system. The traction power system may be divided and tested in sections in accordance with the completion of installation for each system and facility. Continue the energization test until all sections of the traction power system have been tested, up to and including every section of the contact rail system.

D. Emergency/Transfer Trip System (ETTS) Test: Verify the correct functioning of the ETTS equipment in all of its emergency and transfer tripping modes and the proper integration of the ETTS with the following:

1. The DC feeder breakers' control circuits and MPRs.

2. The emergency trip panels (ETPs) associated with the platform trip stations (PTSs) at the project station(s).

3. The emergency trip stations (ETSs) in the wayside blue light stations (BLSs).

Activate each PTS and ETS to verify that the correct contact rail section(s) is/are de-energized. Simulate ETTS equipment failures to confirm that all alarms and status indications function correctly and simulate breaker fault conditions to confirm the correct operation of all transfer tripping functions.

E. Short Circuit, Ground Fault and Train Start Tests: Perform these tests as specified in Contract Specifications Section 34 21 80, Traction Power System Field Acceptance Testing.

3.07 AUTOMATIC TRAIN CONTROL TESTING

A. Perform ATC field and dynamic testing using the ICS and IRAT workstations in the PTC, including train control station to station "Vital" integration testing as specified in

BFS Appendices, “BART Functional Specification, Microprocessor Based Interlocking”, Section 2.8 Testing.

END OF SECTION 20 80 00

ATTACHMENT A TO SECTION 20 80 00

PA / FIRE ALARM / TELEPHONE / SCADA SYSTEM INTERFACE FUNCTIONAL TEST

1.01 TEST OBJECTIVES

A. To verify that the PA system/fire alarm/telephone/SCADA interface performs correctly in response to various fire alarm and phone system conditions

A. Repeat the tests for each station and record the results in the test report.

1.02 PREREQUISITES

A. The PA system installation verification is completed.

B. The installation verification for the PABX and courtesy phone systems is completed.

C. All elevators and escalators are operational.

1.03 TEST PROCEDURE

Step #	Description
1	Activate the “manual pull station” alarm input point at the FACP. Verify that the alarm is reported on the SAB control panel but do not acknowledge the alarm. Verify that 15 seconds later that the message “Escalator about to be stopped” is announced once over the PA system. Verify that the 4-chime code call is broadcast and repeats every 15 seconds (Note – this is typical for all SAB alarms). After one minute, acknowledge the alarm and verify that the 4-chime code call stops. Repeat step A and acknowledge the alarm immediately. Verify that the message is not broadcast over the PA system and that the 4-chime code call is not initiated.
2	At a PABX phone outside of the SAB, make a call to the SAB. Verify that the PABX phone in the SAB rings but do not answer it Verify that 15 seconds later, the 3-chime code call is broadcast and repeats every 15 seconds. After one minute, answer the phone in the SAB and verify that the 3-chime code call stops. Repeat step A and acknowledge the PABX phone call immediately. Verify that the 3-chime code call is not initiated.
3	Press the courtesy phone call button in an elevator. Verify that a single 2-chime code call is broadcast over the PA system. Verify that the courtesy phone in the SAB rings but do not answer it Verify that 15 seconds later, the 2-chime code call is broadcast and repeats every 15 seconds. After one minute, answer the courtesy phone in the SAB and verify that the 2-chime code call stops. Repeat step A and acknowledge the courtesy phone call immediately. Verify that the 2-chime code call is not initiated.

4	Activate the “seismic sensor activated” alarm input point by shorting out the associated terminals in cabinet 44A in each TCR Verify that the alarm is reported on the SAB control panel but do not acknowledge the alarm. Verify that 15 seconds later that the message “Escalator about to be stopped” is announced once over the PA system. Verify that the 6-chime code call is broadcast and repeats every 15 seconds. After one minute, acknowledge the alarm and verify that the 4-chime code call stops. Repeat step A and acknowledge the alarm immediately. Verify that the message is not broadcast over the PA system and that the 4-chime code call is not initiated.

Test Report - PA System-SCADA Interface

Step #	W20	W30	W40	Y10	Comments
1					
2					
3				**N/A**	
4					

Enter a check mark if acceptable; enter N if unacceptable.

Tested by: _____ Date: _____

Witness initials: _____; _____; _____

END OF ATTACHMENT A TO SECTION 20 80 00

SECTION 21 12 00

FIRE-SUPPRESSION STANDPIPE

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Wet standpipe system.

B. Piping accessories.

C. Valves.

D. Gauges.

E. Pipe hanger and support.

F. Fire department connection.

G. Fire hose cabinets.

H. Water flow alarm switch.

I. Drains.

J. Ball drips.

K. Escutcheon.

1.02 RELATED SECTIONS

A. Section 05 70 00, Decorative Metal

B. Section 09 91 00, Painting

C. Section 20 10 13, Common Materials and Methods for Facility Services

D. Section 20 20 13, Pipe Sleeves, Supports, and Anchors for Facility Services

E. Section 20 40 13, Identification for Facility Services

F. Section 33 05 28, Trenching and Backfilling for Utilities

1.03 MEASUREMENT AND PAYMENT

A. General: Separate measurement or payment will not be made for the work required under this Section. Costs in connection with the Work specified herein will be considered to be included or incidental to the Work of this Contract.

1.04 REFERENCES

A. American Society for Testing Materials (ASTM):

1. ASTM A123 — Specification for Zinc (Hot, Dip Galvanized) Coatings on Iron and Steel Products
2. ASTM A153 — Specification for Zinc Coating (Hot, Dip) on Iron and Steel Hardware
3. ASTM A395 — Specification for Ferritic Ductile Iron Pressure Retaining Castings
4. ASTM B16 — Specification for Free-Cutting Brass Rod, Bar, and Shapes for Use in Screw Machines
5. ASTM F437 — Specification for Threaded Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80
6. ASTM F438 — Specification for Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40
7. ASTM F439 — Specification for Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80
8. ASTM F442 — Specification for Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe (SDR-PR)
9. ASTM F493 — Specification for Solvent Cements for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings
10. ASTM D1784 (PVC) — Standard Specification for Rigid Poly (Vinyl Chloride) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds
11. ASTM D2241 — Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series) – Dimensions

B. American Water Works Association (AWWA):

1. AWWA C900-16 — Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings 4 in. through 60 in.

C. American Welding Society (AWS):

1. AWS B2.1/B2.1M — Specification for Welding Procedure and Performance Qualification

D. National Fire Protection Association (NFPA):

1. NFPA 13 Standard for the Installation of Sprinkler Systems
2. NFPA 14 Standard for the Installation of Standpipe and Hose Systems
3. NFPA 24 Standard for the Installation of Private Fire Service Mains and Their Appurtenances
4. NFPA 72 National Fire Alarm and Signaling Code

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit Shop Drawings, hydraulic calculations, and manufacturers' product data, indicating pipe materials used, jointing methods, supports, floor and wall penetration seals and piping layout, valves, fire department connections, fire pumps, maintenance data, hanger locations and details, and recommended spare parts. Shop Drawings shall show the complete system, including construction phasing. Partial submittals will be rejected for resubmission of complete submittals.

C. Certified Test Reports: Submit certified test reports of aboveground and underground piping as indicated in NFPA 13.

D. Product Data: Submit manufacturer's product data for manufactured items of materials and equipment and sprinkler heads.

E. Operation and Maintenance Data: Submit operation and maintenance data for the equipment and system provided, in accordance with Section 01 78 23, Operation and Maintenance Data.

F. State Fire Marshal: Separate Shop Drawings of the wet standpipe system shall be submitted to the State Fire Marshal and the local representative of the State Fire Marshal for approval. Approval shall be obtained before beginning installation work. The Contractor shall submit a copy of the Contractor's transmittal to the State Fire Marshal for the Engineer's information.

1.06 QUALITY ASSURANCE

A. The system installer of subcontractor shall possess a valid C-16 California Contractor's License. The fire suppression system shall be designed by an experienced and qualified individual of firm regularly engaged in the design of fire suppression systems. Drawings and Calculations shall be sealed and stamped by a currently registered California Professional Engineer.

B. Materials shall be clearly marked or stamped with the manufacturer's name, nameplate data or stamp, rating, and conformance with ASTM standards, with corresponding standard number clearly marked, as applicable.

C. Fire protection material and equipment shall be tested and shall be listed by a nationally recognized testing laboratory of fire protection equipment. In addition, valves and grooved fittings shall also be approved for fire protection service by an organization concerned with product evaluations for compliance with appropriate standards for production of listed items.

D. Galvanizing shall conform with the requirements of ASTM A123. Galvanized nuts, bolts, and washers shall conform to the requirements of ASTM A153.

1.07 SITE CONDITIONS

A. Excavations where products will be buried shall be dry. Inspect surfaces and structures where the water supply system will be installed before the work of this Section begins. Provide surfaces and structures capable of supporting the system and its weight.

B. Coordinate the installation of the water supply system with other building systems and components so as to avoid conflicts of installation. Contract Drawings are diagrammatic and not necessarily to scale. Do not scale drawings for exact locations of installation of pipelines, valves, and equipment.

PART 2 – PRODUCTS

2.01 WET STANDPIPE SYSTEM

A. The system shall be provided as indicated and shall conform with NFPA 14 and the approved Shop Drawings.

2.02 EXPOSED AND EMBEDDED PIPE AND FITTINGS

A. Aboveground (except Parking Structures): Class S, as specified in Section 20 10 13, Common Materials and Methods for Facility Services – Fire Suppression, Plumbing and HVAC.

B. Aboveground in Parking Structures: Class R, as specified in Section 20 10 13, Common Materials and Methods for Facility Services – Fire Suppression, Plumbing and HVAC.

C. Underground: Class K, as specified in Section 20 10 13, Common Materials and Methods for Facility Services – Fire Suppression, Plumbing and HVAC.

D. Underground: Class T, as specified in Section 20 10 13, Common Materials and Methods for Facility Services – Fire Suppression, Plumbing and HVAC.

2.03 PIPING ACCESSORIES

A. Provide piping accessories of types and sizes as indicated.

B. Provide piping passing through floors, walls, and ceilings with chrome split-wall plates.

C. Place flexible connections above and below each riser valve assembly, and between exposed and embedded piping.

2.04 VALVES

A. Refer to Section 20 10 13, Common Materials and Methods for Facility Services – Fire Suppression, Plumbing and HVAC, for check valves, butterfly valves, air release valves, angle valves, and valve supervisory switches. Main system isolation valve shall be located inside the building at the utility entrance and shall be an OS&Y valve.

2.05 GAUGES

A. 3 1/2 inch dial type conforming with NFPA 14.

2.06 PIPE HANGER AND SUPPORT

A. Furnish and install in accordance with Section 20 20 13, Pipe Sleeves, Supports, and Anchors for Facility Services.

B. Seismic and Support Requirements:

1. Seismic bracing, anchorages, and reinforcements shall be provided for equipment and piping in accordance with the California Building Code, NFPA 13 and Appendix A, NFPA 14 and local code standards and regulations. Equipment and piping shall be anchored to withstand forces generated by earthquake movement.
2. The seismic bracing shown on the drawings sets forth minimum requirements. Contractor shall furnish and install additional seismic bracing at:
    a. Base and top of risers in conjunction with supports to prevent uplift,
    b. Changes in direction,
    c. Offsets with emphasis on restraining longitudinal motion,
    d. On longitudinal piping supported by clevis type hangers exceeding 6 inch distance between pipe centerline and mounting surface,
    e. On longitudinal piping supported by angle bracket type hangers exceeding 8 inch distance between pipe centerline and mounting surface, and
    f. At other locations in accordance with NFPA 13 and appendices thereto. Seismic bracing shall be designed to prevent both transverse and longitudinal displacement forces with lateral bracing located at a maximum of 40 foot on center and longitudinal bracing located at a maximum of 80-foot on center.

3. Pipe hanger supports shall be capable of supporting a total weight equal to five times the weight of the equipment or pipe, full of water, plus weight of valves and fittings attached, plus 250 pounds with the force acting at the pipe center or equipment center of gravity. Only clevis or minimum 1/4 inch thick by times 2 inch wide fabricated steel hangers that are hot dipped galvanized after fabrication shall be used and all nuts shall be nylon-insert locknuts or threads coated with Engineer approved adhesive. Adhesive shall be blue or red and shall be visible after installation.

2.07 FIRE DEPARTMENT CONNECTION

A. Provide two-way brass or bronze, wall or flush type, with “knock-off” caps, conforming to NFPA 14. Provide self-closing clapper valve in each inlet, and local fire department inlet hose threads.

B. Fire department connection shall be labeled as WET STANDPIPE in raised cast letters on surface of fitting, wall plate or escutcheon. Labels shall include “BART” along with service design. Exposed parts, including escutcheon, shall have high visible red painted finish.

2.08 FIRE HOSE CABINETS

A. Free-standing fire hose cabinets on platforms and concourses shall comply with the requirements of Section 05 70 00, Decorative Metal.

B. Recessed fire hose cabinets in public areas shall be of similar construction to the cabinets in Section 05 70 00, Decorative Metal. In parking structure and non-public area recessed fire hose cabinets shall be 18 gauge, Type 304 stainless steel construction with solid door with continuous stainless steel hinge. Provide No. 4 finish on visible exterior surfaces. Cabinet locations shall be as indicated.

C. In parking structures and non-public areas surface mounted fire hoses cabinets may be used. Surface mounted fire hose cabinets shall be 18 gauge, Type 304 stainless steel construction with solid door and continuous stainless steel hinge. Provide No. 4 finish on visible exterior surfaces. Fire hose cabinet locations shall be as indicated on the Contract Drawings. Fire hose cabinet doors shall be 12 gauge Type 304 stainless steel, positive latch device and labeled “FIRE HOSE” and “FIRE EXTINGUISHER” using uppercase Univers 65 typeface with a capital letter height of 1 inch. Submit Shop Drawings for layout approval.

D. Each cabinet shall contain a 1 1/2 inch cast-brass angle hose valve with 100 feet of 1 1/2 inch polyurethane lined, synthetic jacketed hose, mildew and rot-resistant, complete with cast-brass nipple and coupling, 1 1/2 inch red body with black bumper polycarbonate fog nozzle, hose rack, 2 1/2 inch cast-brass angle-hose valve body with 2 1/2 inch or 3 inch outlet (depending upon requirements of local fire department) with fire department hose thread end and cap with chain, escutcheon plates and spanner wrench and fire extinguisher. Hose Rack: Steel with polished chrome finished, swivel type with pins and water stop. The outlet of the 2 1/2 inch hose valve shall have a brass reducer with 2 1/2 inch female to 1 1/2 inch male, National Standard Thread (NST) for fire hose, and a 1 1/2 inch brass cap and chain. Provide minimum 1 1/2 inch clearance between valve and cabinet.

2.09 WATER FLOW ALARM SWITCH

A. Provide a switch that will indicate the flow of water in the standpipe system, conforming to NFPA 72.

2.10 DRAINS

A. Provide pipe to discharge at sight cones attached to drains of adequate size, to readily care for the full flow from each drain under maximum pressure.

2.11 BALL DRIPS

A. Provide automatic ball drips manufactured as cast brass automatic drip connections, that close at approximately seven to ten psi on inlet side of check valve on Fire Department Connections.

2.12 ESCUTCHEON

A. Provide split hinged, locking type escutcheon held in place by either internal tension spring or a set screw. Provide polished chromium-plated pressed steel material. Escutcheon shall encompass the sleeve or opening.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Excavating and backfilling, including bedding and compacting requirements, shall conform to Section 33 05 28, Trenching and Backfilling for Utilities.

B. Provide concrete thrust blocks for elbows, tees, valves, and appurtenances on buried piping. Thrust blocks shall be constructed as indicated.

C. Install the wet standpipe system as indicated and in accordance with applicable requirements of NFPA 14.

D. Install pipe, fittings, and valves without springing or forcing. Flanged joints shall be made up with a torque wrench and by tightening every other bolt around the flange, then by tightening the remaining bolts; bolt holes of flanges on horizontal pipe shall straddle pipe centerlines. Install anchors as indicated. Provide swing joints or flexible connections for transitions from embedded to exposed pipe.

E. Install piping true to line and grade, and support and guide piping to ensure alignment under all conditions. Installed piping shall clear obstructions, preserve headroom, and keep openings and passageways clear.

F. Make changes in direction of piping with manufactured fittings. Provide branch connections with either screwed or grooved end fittings. Welding shall be permitted for flanged connections and shall be in accordance with AWS B2.1/B2.1M. Welding outlets shall be a forged weldolet type fitting and shall be permitted for use at main drain connections, and main line gage connections only.

G. Welding shall be performed only in the shop and shall conform to AWS B2.1/B2.1M. Field welding will not be permitted.

1. Align component parts to be welded in a manner that will ensure that no strain will be placed on the area to be welded. Do not offset pipe wall by more than 20 percent of the wall thickness. Preserve alignment during the welding operation. Provide tack welds of the same quality, and applied by the same procedure, as the completed weld. Otherwise, remove tack welds during the welding operation.

2. Remove defective welds, and provide new welds as required, at no additional cost to the District.

3. Electrodes shall be stored in a dry heated area. Electrodes shall be kept free of moisture and dampness during fabrication operations. Discard electrodes that have lost part of their coating.

H. Install standpipe piping so that it can be thoroughly drained and, where practicable, arranged to drain at the main drain valves.

I. Valves shall be accessible for operation and servicing. Valves located in furred spaces shall be accessible through access panels or access doors. Valves shall be installed as indicated, and shall have no stems located below the horizontal position.

J. Provide escutcheon plates at finished surfaces where exposed piping passes through floors, walls, and ceilings. Fasten escutcheons to pipe or pipe coverings.

K. Free-standing and recessed fire hose cabinets shall be installed in accordance with Section 05 70 00, Decorative Metal. Surface-mounted fire hose cabinets shall be installed in accordance with manufacturer’s requirements.

L. Piping system shall be free from grease, oil, rust and scale, and properly prepared for the application of paint. Paint standpipe system as specified in Section 09 91 00, Painting.

M. Make provisions for expansion and contraction of pipe lines, and longitudinal, and lateral movement per Section 2.06. Apply couplings and or seismic separation assemblies as per NFPA 13 Sections 9.2.3 and 9.3.3 and at structural joints or separations.

N. Pipe and fittings shall be free from fins and burrs. Threaded joints shall have a lubricant applied on the male threads only. Threads shall be full cut, and not more than three threads on the pipe shall remain exposed.

O. Route piping in orderly manner, plumb and parallel to structure. Maintain gradient.

P. Install piping to conserve space, to not interfere with use of space and other work.

Q. Group piping whenever practical at common elevations.

R. Sleeve pipes passing through partitions, walls, and floors.

S. Inserts:

1. Provide inserts for placement in concrete formwork.

2. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.

3. Where concrete slabs form finished ceiling, locate inserts flush with bottom slab surface.

4. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut recessed into and grouted flush with slab.

T. Pipe Hangers and Supports:

1. Install in accordance with NFPA 13 and NFPA 14.

2. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.

3. Place hangers within 12 inches of each horizontal elbow.

4. Use hangers with 1 1/2 inch minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.

5. Support vertical piping at every floor or building level. Support riser piping independently of connected horizontal piping.

6. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.

U. Slope piping and arrange systems to drain at low points. Use eccentric reducers to maintain top of pipe level.

V. Prepare pipe, fittings supports, and accessories to finish painting. Where pipe support members are welded to structural framing, scrape, brush clean, and apply one coat of zinc rich primer to welding. Refer to Section 09 91 00, Painting.

W. Do not penetrate structural members unless indicated.

X. Die cut threaded joints with full cut standard taper pipe threads with red lead and linseed oil or other non-toxic joint compound applied to male threads only.

Y. Install approved back flow preventer assembly at wet-standpipe system water source connection.

3.02 PAINTING

A. Except where indicated, piping systems shall not be painted. Where pipes are indicated to be painted, prepare pipe in accordance with Section 09 91 00, Painting.

3.03 IDENTIFICATION

A. Comply with the requirements of Section 20 40 13, Identification for Facility Services.

3.04 FIELD QUALITY CONTROL

A. System shall be inspected for compliance with these Specifications.

B. Test installed systems and products hydrostatically, using testing instruments calibrated by a qualified laboratory in accordance with Section 01 45 00, Quality Control, and flush in accordance with applicable requirements of NFPA 13 and NFPA 14. Repair leaks.

C. The Contractor shall perform tests in the presence of the Engineer and shall furnish items used in testing. The Contractor shall give 48 hour notice prior to test. The Engineer will review certificates and test reports, and will inspect the wet standpipe system to verify conformance with NFPA 14. Test shall be witnessed by BART.

D. Provide system flushing at rate conforming to NFPA 24.

E. Provide a complete set of signed hydrostatic testing and system flushing documents in a tabbed binder or in the O&M manual at completion of job.

3.05 TRAINING

A. Refer to Section 01 79 00, Demonstration and Training, for maintenance personnel training requirements.

END OF SECTION 21 12 00

SECTION 21 13 13

WET-PIPE SPRINKLER SYSTEM

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Wet pipe automatic sprinkler system.

B. Undercar deluge system.

C. Exposed and embedded pipe and fittings.

D. Pipe hangers and support.

E. Valves.

F. Fire department connection.

G. Sprinkler heads.

H. Signs.

I. Tools and spare parts.

J. Inspector's test valves.

K. Waterflow indicating switch.

1.02 RELATED SECTIONS

A. Section 09 91 00, Painting

B. Section 20 10 13, Common Materials and Method for Facility Services

C. Section 20 20 13, Pipe Sleeves, Supports, and Anchors for Facility Services

D. Section 20 40 13, Identification for Facility Services

E. Section 28 31 00, Fire Detection and Alarm System

F. Section 33 05 28, Trenching and Backfilling for Utilities

1.03 MEASUREMENT AND PAYMENT

A. General: Separate measurement or payment will not be made for the work required under this Section. Costs in connection with the Work specified herein will be considered to be included or incidental to the Work of this Contract.

1.04 REFERENCES

A. American Society for Testing Materials (ASTM):

1. ASTM A123 Specification for Zinc (Hot Dip Galvanized) Coatings on Iron and Steel Products
2. ASTM A153 Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware
3. ASTM A395 Specification for Ferritic Ductile Iron Pressure Retaining Castings
4. ASTM A582 Specification for Free-Standing Stainless and Heat-Resisting Steel Bars, Hot Rolled or Cold Finished
5. ASTM B16 Specification for Free-Cutting Brass Rod, Bar, and Shapes for Use in Screw Machines

B. American Welding Society (AWS):

1. AWS D10.9 Specification for Qualification of Welding Procedures and Welders for Piping and Tubing

C. National Fire Protection Association (NFPA):

1. NFPA 13 Standard for the Installation of Sprinkler Systems
2. NFPA 14 Standard for the Installation of Standpipe and Hose Systems
3. NFPA 15 Water Spray Fixed Systems for Fire Protection
4. NFPA 24 Private Fire Service Mains and Their Appurtenances
5. NFPA 72 National Fire Alarm Code

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit Shop Drawings and Calculations to include the following requirements:

1. Current water flow information;
2. Hydraulic calculations;

3. Sprinkler piping on plans and sections to scale;

4. Sprinkler head locations coordinated with reflected ceiling plans;

5. Hanger locations and details; and

6. Accessory locations and details (such as valves and gages).

7. Shop Drawings shall show the complete system, including construction phasing, pipe materials used, jointing methods, supports, floor and wall penetration seals, and sprinkler locations. Partial submittals will be rejected for resubmission of complete submittals.

8. Refer to Article entitled “Quality Assurance” herein for requirement that Drawings and Calculations be signed and stamped by professional engineer.

C. Product Data: Submit manufacturers’ product data for manufactured items of materials and equipment and sprinkler heads.

D. Certificates of Compliance: Submit such certified test reports for materials and equipment as necessary to demonstrate compliance with specification requirements.

E. Operation and Maintenance Data: Submit operation and maintenance data for the equipment and system provided, in accordance with Section 01 78 23, Operation and Maintenance Data. Include recommended spare parts list.

F. Certified Test Reports: Submit certified test reports on Contractor’s Material and Test certificate for aboveground and underground piping as shown in NFPA 13.

G. State Fire Marshal: Separate Shop Drawings of the fire protection automatic sprinkler system shall be submitted to the State Fire Marshal and the local representative of the Fire Marshal for approval. Approval shall be obtained before beginning installation work. The Contractor shall submit a copy of the Contractor’s transmittal to the State Fire Marshal for the Engineer’s information.

1.06 QUALITY ASSURANCE

A. The system installer shall possess a valid C-16 California Contractor’s License. The fire suppression system shall be designed by an experienced and qualified individual of firm regularly engaged in the design of fire suppression systems. Drawings and calculations shall be signed and stamped by a registered California Professional Engineer.

B. Materials shall be clearly marked or stamped with the manufacturer’s name, nameplate data or stamp, rating, and conformance with ASTM standards, with corresponding standard number clearly marked, as applicable.

C. Fire protection material and equipment shall be tested and shall be listed by a nationally recognized testing laboratory of fire protection equipment. In addition, valves and grooved fittings shall also be approved for fire protection service by an organization concerned with product evaluations for compliance with appropriate standards for production of listed items.

D. Galvanizing shall conform to the requirements of ASTM A123. Galvanized nuts, bolts, and washers shall conform to the requirements of ASTM A153.

1.07 SITE CONDITIONS

A. Excavations where products will be buried shall be dry. Inspect surfaces and structures where the water supply system will be installed before the work of this Section begins. Provide surfaces and structures capable of supporting the system and its weight.

B. Coordinate the installation of the water supply system with other building systems and components so as to avoid conflicts of installation. Contract Drawings are diagrammatic and not necessarily to scale. Do not scale drawings for exact locations of installation of pipelines, valves, and equipment.

PART 2 – PRODUCTS

2.01 WET PIPE AUTOMATIC SPRINKLER SYSTEM

A. Design Standards: Design the automatic sprinkler system in accordance with NFPA 13 for a minimum Ordinary Hazard Group II using a hydraulically designed system.

B. Areas Requiring Protection:

1. Office buildings, main repair shop with offices, training centers, control towers, transportation buildings, and storage buildings.

2. Vent shaft structures; and all public areas at below grade stations, all station ancillary spaces (except electrical rooms, train control and communications rooms, traction power substations, and auxiliary power rooms), including fan rooms, valve rooms, storage rooms, corridors, rest rooms, offices, unassigned spaces, and stairwells, shall be provided with automatic sprinkler protection. Provide as indicated for other structures.

C. Coordinate with applicable work per Section 28 31 00 Fire Detection and Alarm System to ensure that the systems are properly interfaced, supervised, and controlled.

2.02 UNDERCAR DELUGE SYSTEMS

A. Provide undercar deluge systems as required in the CBC and at all stations with platform levels that are below grade.

B. The undercar deluge systems, five zones per track, shall be hydraulically designed in accordance with NFPA 15. The systems shall be designed for remote manual activation.

C. Each zone shall be designed to provide a minimum of 250 gpm to the underside of a two vehicle pair.

D. Coordinate with applicable work per Section 28 31 00 Fire Detection and Alarm System to ensure that the systems are properly interfaced, supervised, and controlled.

2.03 EXPOSED AND EMBEDDED PIPE AND FITTINGS

A. Aboveground except parking structures: Class S, as specified in Section 20 10 13, Common Materials and Methods for Facility Services, Fire Suppression, Plumbing and HVAC.

B. Aboveground in all parking structures: Class R, as specified in Section 20 10 13, Common Materials and Methods for Facility Services, Fire Suppression, Plumbing and HVAC.

C. Underground: Class K for four inches and larger pipe, Class H for three inches and smaller pipe, as specified in Section 20 10 13, Common Materials and Methods for Facility Services, Fire Suppression, Plumbing and HVAC.

D. Underground connections shall be bell and spigot, socket welded, mega-lug type or flanged. All underground connections shall have rods and clamps installed or be reinforced with properly designed thrust blocks. Mega-lug type connections shall be reinforced with thrust blocks.

E. Underground piping connections to above ground or exposed piping shall be by means of a ductile iron riser with flanged connections as indicated in Specification 20 10 13, Article 2.01I, Class I.

2.04 PIPING ACCESSORIES

A. Provide piping accessories of type and size as indicated.

B. Provide piping passing through floors, walls, and ceilings with chrome split wall plates.

C. Place flexible connections above and below each riser valve assembly, and between exposed and embedded piping.

2.05 PIPE HANGERS AND SUPPORT

A. Furnish and install in accordance with Section 20 20 13, Pipe Sleeves, Supports, and Anchors for Facility Services. The provisions below may be more stringent than those of Section 20 20 13, Pipe Sleeves, Supports, and Anchors for Facility Services. The more stringent provision shall apply.

B. Seismic and Support Requirements:

1. Seismic bracing, anchorages and reinforcements shall be provided for equipment and piping in accordance with the California Building Code, NFPA 13 and Annex A, NFPA 14 and local code standards and regulations.

2. The seismic bracing shown on the drawings sets forth the minimum requirements. Contractor shall furnish and install additional seismic bracing at:

   a. Base and top of risers in conjunction with supports to prevent uplift;

   b. Changes in direction;

   c. Offsets with emphasis on preventing longitudinal motion;

   d. On piping supported by clevis type hangers exceeding six inch distance between pipe centerline and mounting surface;

   e. On piping supported by angle bracket type hangers exceeding eight inch distance between pipe centerline and mounting surface; and

   f. At other locations in accordance with NFPA 13 and appendices thereto. At a minimum, seismic bracing shall be designed to prevent both transverse and longitudinal displacement forces with lateral bracing located 40 foot on center and longitudinal bracing 80 foot on center.

3. Pipe hanger supports shall be capable of supporting a total weight equal to five times the weight of the equipment or pipe, full of water, plus weight of valves and fittings attached, plus 250 pounds with the force acting at the pipe center or equipment center of gravity. Only clevis or minimum 1/4 inch thick by two inch wide fabricated steel hangers that are hot dipped galvanized after fabrication shall be used and all nuts shall be nylon lock tight or threads coated with Engineer approved adhesive.

2.06 VALVES

A. Refer to Section 20 10 13, Common Materials and Methods for Facility Services, Fire Suppression, Plumbing and HVAC, for valves of types, sizes, and configurations indicated. Gate and butterfly valves shall indicate the open or closed position to water flow. Provide gate and butterfly valves, with electric switch that will be positioned by the valve stem so that open or closed position of valve can be remotely monitored. Main system isolation valve shall be located inside the building at the utility entrance and shall be an OS&Y valve.

B. Alarm check valve may be used in lieu of check valve and water flow indicating switch. Valve shall be provided with trim for variable pressure installation and shall be provided with alarm pressure switch. Coordinate switch configuration and contact rating with applicable requirements of Division 20, Facility Services and Division 26, Electrical.

C. Drain Valves:

1. Compression Stop: Bronze with hose thread nipple and cap.

2. Ball Valve: Brass with cap and chain, 3/4 inch, hose thread.

2.07 FIRE DEPARTMENT CONNECTION

A. Provide two-way brass or bronze, wall or flush type, with inlet plugs and chains or caps, conforming with NFPA 13. Provide self closing clapper valve in each inlet, and local fire department inlet hose threads.

B. Fire department connection shall be labeled as AUTO SPRINKLER in raised cast form on surface of either fitting or escutcheon. Labels shall include “BART” along with service design. Exposed parts, including escutcheon, shall have either polished brass or polished chromium plated finish.

2.08 SPRINKLER HEADS

A. In areas without ceilings, sprinkler heads shall be standard coverage glass bulb style (upright, pendant, side wall) as required for the particular application, 1/2 inch discharge orifice, ordinary temperature rating, unless otherwise indicated or required.

B. In areas with ceilings, sprinkler heads shall be flush style, 1/2 inch discharge orifice, ordinary temperature rating, unless otherwise indicated or required.

C. Undercar deluge spray nozzles shall be wide angle spray type, equipped with dust cap.

2.09 SIGNS

A. Provide signs and identification as specified in Section 20 40 13, Identification for Facility Services, and in conformance with NFPA 13. Attach signs and identification to each valve required to be identified.

2.10 TOOLS AND SPARE PARTS

A. Provide each system with sprinkler cabinet and six of each type of sprinkler heads of the types and ratings installed, a sprinkler wrench, and a pair of sprinkler tongs.

2.11 INSPECTOR’S TEST VALVES

A. Test valve shall be supplied from the highest and most remote part of the system in relation to the riser assembly. Installed test valve shall be within 7 feet of the floor.

2.12 WATERFLOW INDICATING SWITCH

A. Provide waterflow indicating switch as indicated, conforming to NFPA 72. Coordinate switch configuration and contact rating with applicable requirements of Division 20, Facility Services and Division 26, Electrical.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Excavating and backfilling, including bedding and compacting requirements, shall conform to Section 33 05 28, Trenching and Backfilling for Utilities.

B. Provide concrete thrust blocks for elbows, tees, valves, and appurtenances on buried piping. Thrust blocks shall be constructed as indicated.

C. Install products as indicated and in accordance with NFPA standards referenced in Article 1.04, as applicable.

D. Install pipe, fittings, and valves without springing or forcing. Apply pipe compound to male threads. Flanged joints shall be made up with a torque wrench and by tightening every other bolt around the flange, then by tightening the remaining bolts; bolt holes of flanges on horizontal pipe shall straddle pipe centerlines. Install anchors as indicated. Provide swing joints or flexible connections for transitions from embedded to exposed pipe.

E. Install piping true to grade and line. Support and guide piping to ensure alignment under all conditions. Installed piping shall clear obstructions, preserve headroom, and keep openings and passageways clear.

F. Make changes in direction of piping with manufactured fittings. Provide branch connections with either threaded or grooved fittings. Welding shall be permitted for flange connections. Welding outlets that are forged weldolet type fittings shall be permitted for use at sprinkler outlets to branch line connections (3/4 inch and smaller), main line gauge connections (1/2 inch and smaller), and main drain connections only.

G. Welding shall be performed only in the shop. Welders shall be qualified in accordance with AWS D10.9. Field welding will not be permitted.

1. Align component parts to be welded in a manner that will ensure that no strain will be placed on the area to be welded. Do not offset pipe wall by more than 20 percent of the wall thickness. Preserve alignment during the welding operation. Provide tack welds of the same quality, and applied by the same procedure, as the completed weld. Otherwise, remove tack welds during the welding operation.

2. Remove defective welds and provide new welds as required at no additional cost to the District.

3. Electrodes shall be stored in a dry heated area. Electrodes shall be kept free of moisture and dampness during fabrication operations. Discard electrodes that have lost part of their coating.

H. Provide installed sprinkler piping that is capable of being thoroughly drained and, where practicable, is arranged to drain at the main drain valves.

I. Valves shall be accessible for operation and servicing. Valves located in furred spaces shall be accessible through access panels or access doors. Valves shall have no stems located below the horizontal position.

J. Provide escutcheon plates at finished surfaces where exposed piping, bare or insulated, passes through floors, walls, and ceiling. Fasten escutcheon to pipe or pipe covering.

K. Install sprinkler heads upright. Orient directional heads to spray the space indicated.

L. Route piping in orderly manner, plumb and parallel to structure. Maintain gradient.

M. Install piping to conserve space, to not interfere with use of space and other work.

N. Group piping whenever practical at common elevations.

O. Sleeve pipes passing through partitions, walls, and floors.

P. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

Q. Inserts:

1. Provide inserts for placement in concrete formwork.

2. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.

3. When concrete slabs form finished ceiling, locate inserts flush with bottom slab surface.

4. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut recessed into and grouted flush with slab.

R. Pipe Hangers and Supports

1. Install in accordance with NEPA 13 and NFPA 14.

2. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.

3. Place hangers within 12 inches of each horizontal elbow.

4. Use hangers with 1/2 inch minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.

5. Support vertical piping at every floor or building level. Support riser piping independently of connected horizontal piping.

6. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.

S. Slope piping and arrange systems to drain at low points. Use eccentric reducers to maintain top of pipe level.

T. Prepare pipe, fittings, supports, and accessories to finish painting. Where pipe support members are welded to structural framing, scrape, brush clean, and apply one coat of zinc rich primer to welding. Refer to section 09 01 00, Painting.

U. Do not penetrate structural members unless indicated.

V. Die cut threaded joints with full cut standard taper pipe threads with red lead and linseed oil or other non-toxic joint compound applied to male threads only.

W. Install approved backflow preventer assembly at wet-standpipe system water source connection.

3.02 PAINTING

A. Except where indicated, piping systems shall not be painted. Where pipes are indicated to be painted, prepare pipe in accordance with Section 09 91 00, Painting. Provide protective covering to keep paint away from the sprinkler heads. Protective covering shall be removed under Section 09 91 00, Painting.

3.03 IDENTIFICATION

A. Comply with the requirements of Section 20 40 13, Identification for Facility Services.

3.04 FIELD QUALITY CONTROL

A. System shall be inspected and tested in accordance with NFPA 13 and compliance with these Specifications. Inspections and tests shall be documented by properly completing the appropriate NFPA form. These form or certificates (see NFPA 13) shall be filled out and signed by all representatives and copies shall be prepared and submitted to all representatives.

B. Test installed systems and products hydrostatically, using testing instruments calibrated by a qualified laboratory in accordance with Section 01 45 00, Quality Control, and flush in accordance with applicable requirements of NFPA 13. Repair leaks.

C. The Contractor shall perform all tests in the presence of the Engineer and shall furnish all items used in testing. The Contractor shall give 48 hour notice prior to test. The Engineer will review certificates and test reports, and will inspect the automatic sprinkler system to verify conformance with NFPA 13. Test will be witnessed by BART.

D. Provide system flushing at rate conforming to NFPA 24.

E. Provide a complete set of all signed hydrostatic test and flushing documents in a tabbed binder or in the Operations and Maintenance manual at completion of the job.

F. At the completion of installation, testing, and training the system shall be commissioned. A letter clearly stating that all articles indicated under systems acceptance of the appropriate NFPA Code shall be signed and sealed by the Engineer of Record submitted to the District.

3.05 TRAINING

A. Refer to Section 01 79 00, Demonstration and Training, for maintenance personnel training requirements.

3.06 PROTECTION OF INSTALLED CONSTRUCTION

A. Apply masking tape or paper cover to protect concealed sprinklers, cover plates, and sprinkler escutcheons not receiving field paint finish, remove after painting. (Replace painted sprinklers with new).

END OF SECTION 21 13 13

SECTION 21 22 00

CLEAN AGENT FIRE EXTINGUISHING SYSTEM

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Alarm operation description.

B. Trouble operation description.

C. Control and supervisory systems.

D. Fire suppression agent.

E. Agent storage and distribution components.

F. Signs and identification.

G. Pipe fittings, wire, and conduit.

1.02 RELATED SECTIONS

A. Section 01 33 00, Submittal Procedures

B. Section 01 33 23, Shop Drawings, Product Data, and Samples

C. Section 01 60 00, Product Requirements

D. Section 01 77 00, Closeout Procedures

E. Section 01 78 23, Operation and Maintenance Data

F. Section 01 79 00, Demonstration and Training

G. Section 07 90 00, Joint Protection

H. Section 09 91 00, Painting

I. Section 20 40 13, Identification for Facility Services

J. Section 20 50 13, Raceway for Facility Services

K. Section 26 05 24, Low Voltage Wires and Cables

1.03 MEASUREMENT AND PAYMENT

A. General: Separate measurement or payment will not be made for the work required under this Section. Costs in connection with the Work specified herein will be considered to be included or incidental to the Work of this Contract.

1.04 DESCRIPTION

A. Each room to be protected shall be considered a single zone for fire suppression protection.

B. Minimum design concentration requirements shall be Class C per NFPA 2001 Table A.5.4.2.2(b). Clean agents shall maintain minimum design concentrations for at least ten minutes. Such factors as unclosable openings (if any), “rundown” time for fans, time required for dampers to close, and all other features of the facility that could affect concentration shall be considered.

C. The design discharge time shall not exceed ten seconds.

D. Design and operation of the system shall comply at a minimum with the appropriate requirements of NFPA 2001 and the requirements of the nationally recognized testing authorities for which listings or approvals have been obtained.

E. Fire Protection System: Total flooding of hazard area with fire extinguishing agent, to extinguishing fire.

F. Locate extinguishing agent supply and back-up supply in each hazard area.

G. System is fixed installation with equipment designed and installed to provide fire-extinguishing capability for the area as indicated.

1.05 MEASUREMENT AND PAYMENT

A. General: Clean agent fire suppression system will not be measured separately for payment but will be paid for as part of the Contract lump-sum price for Mechanical Work.

1.06 REFERENCES

A. California Code of Regulations, Title 24, Part 3, California Electrical Code

B. California State Fire Marshal (CSFM):

1. Building Materials Listing Program

C. American Society of Mechanical Engineers (ASME):

1. ASME B16.3 Malleable Iron Threaded Fittings
2. ASME B16.18 Cast Copper Alloy Solder Joint Pressure Fittings
3. ASME B16.22 Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
4. ASME B31.1 Power Piping
5. ASME B40.1 Gages – Pressure Indicating Dial Type – Elastic Element

6. ASME — Boiler and Pressure Vessel Code, Section VIII, Division 1 – Rules for Construction of Pressure Vessels

7. ASME — Boiler and Pressure Vessel Code, Section IX – Welding and Brazing Qualifications

D. American Society for Testing and Materials (ASTM):

1. ASTM A53 — Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc Coated, Welded and Seamless

2. ASTM A106 — Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service

3. ASTM A135 — Standard Specification for Electric-Resistance-Welded Steel Pipe

4. ASTM A234/A234M — Standard Specification for Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures

5. ASTM B32 — Standard Specification for Solder Metal

6. ASTM B88 — Standard Specification for Seamless Copper Water Tube (ASTM B88M – Standard Specifications for Seamless Copper Water Tube (Metric)

E. American Welding Society (AWS):

1. AWS A5.8 — Specifications for Filler Metal for Brazing and Braze Welding

2. AWS D1.1 — Structural Welding Code – Steel

F. National Electrical Manufacturers Association (NEMA):

1. NEMA ICS 6 — Industrial Control and Systems: Enclosures

G. National Fire Protection Association (NFPA):

1. NFPA 70 — National Electrical Code

2. NFPA 72 — National Fire Alarm Code

3. NFPA 75 — Electronic Computer Rooms

4. NFPA 2001 — Clean Agent Fire Extinguishing Systems

H. Underwriters Laboratories Inc. (UL):

1. UL 393 Indicating Pressure Gages for Fire-Protection Service

2. UL 404 Gages, Indicating Pressure, for Compressed Gas Service

1.07 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings and Data:

1. All drawings and calculations shall be prepared in accordance with NFPA 2001. Refer to Article entitled “Quality Assurance” herein for requirement that drawings and calculations be signed and stamped by professional engineer.

2. Drawings shall bear stamp of approval of authority having jurisdiction and shall indicate locations, installation details, and operation details of all equipment and piping, control diagram, wiring diagram and sequence of operation associated with the fire suppression system.

3. Piping plan view and detail drawings shall be drawn to scale and isometrics dimensioned to show the entire storage and distribution system, the nozzle and detector location, and layout of annunciator final graphics. The detector and nozzle locations shall be coordinated with lighting fixtures, diffusers, ductwork, and other equipment installed in the protected room. Indicate manual pull station, control panel, and accessory locations and details.

4. Electrical drawings shall indicate the complete sequence of operations of the system, termination diagrams and locations of interfaces with other systems.

5. Calculations shall be submitted demonstrating that the proposed system can provide the design concentration within the design discharge time. Submit design calculations bearing stamp of approval of authority having jurisdiction.

6. Calculations shall be submitted showing required battery capacity, verify system pressure, nozzle flow rate, orifice code numbers, piping pressure losses, component flow data and pipe sizes.

7. Indicate any required construction phasing.

C. California State Fire Marshal: Shop Drawings of the clean agent fire suppression system shall be submitted to the Engineer for submission to the State Fire Marshal for approval. Include State Fire Marshal listing numbers, as listed in the State Fire Marshal’s Building Materials Listing Program, for all components. Shop Drawings require approval of the State Fire Marshal before any installation work may begin.

D. Certificates of Compliance: Submit certified test reports for materials and equipment to demonstrate compliance with specification requirements.

E. Product Data: Material and equipment information shall include manufacturer's catalog cuts and technical data for each of the following components or devices used in the system and shall bear stamp of authority having jurisdiction:

1. Smoke sensors;
2. Manual discharge switches (pull stations);
3. Control panel;
4. Release devices;
5. Alarm devices;
6. Storage containers;
7. Mounting brackets;
8. Nozzles;
9. Abort stations; and
10. Contact monitor modules.

F. Operation and Maintenance Data: Submit operation and maintenance data for the equipment and system provided in accordance with Section 01 78 23, Operation and Maintenance Data. Include recommended spare parts list.

G. Certified Test Reports: Submit certified test reports that indicate successful completion of all tests performed as required by Article 3.04 herein.

H. Manufacturer: Certify that system meets or exceeds specified requirements and NFPA 2001.

1.08 QUALITY ASSURANCE

A. Qualifications of the System Designer and Installer:

1. The system installer or subcontractor for this work shall possess a valid C-16 California Contractor's License. The fire suppression system shall be designed by an experienced and qualified individual or firm regularly engaged in the design of clean agent fire extinguishing systems. Drawings and calculations shall be signed and sealed by a registered California Professional Engineer.
2. The installer shall maintain a 24-hour, seven-day-a-week telephone number for emergencies. Factory-trained personnel shall be kept on call for emergency service at all times.

B. Identification of Materials and Equipment: Materials and equipment shall be clearly marked or stamped with the manufacturer's name, nameplate data or stamp, rating, and conformance with corresponding standard number, as applicable.

C. Perform work in accordance with NFPA 70 and NFPA 72, applicable UL standards and requirements of applicable codes and ordinance.

D. Indicate manufacturer's name and pressure rating on valve body. Indicate manufacturer, type and size, part number, orifice code or orifice diameter on discharge nozzles. Markings shall be standard and visible after installation.

E. Certified Tests and Listings: Fire protection material and equipment shall be approved or listed by a nationally recognized testing laboratory of fire protection equipment for this application.

F. Equipment and devices of the system shall be of identical type, model and manufacturer as submitted and shall be approved by the California State Fire Marshal.

G. Components of the system, as listed in Article 1.06.E herein, shall be the products of one manufacturer.

H. Equipment shall be new and shall be of the most current design available from the manufacturer.

I. Welding Materials and Procedures: Conform to ASME Section IX.

1.09 DESIGN REQUIREMENTS

A. Provide sufficient amount of fire extinguishing agent liquid to convert into fire extinguishing agent vapor. Consider the following when computing volume:

1. Volume of hazard area.

2. Specific volume of fire extinguishing agent vapor.

3. Additional quantities of fire extinguishing agent required to compensate for openings, pipe losses, and nitrogen dilution.

4. Forced ventilation, fan coast-down time, and damper actuation time.

5. Mechanical smoke control system.

6. Other special conditions affecting extinguishing efficiency.

B. Interface system with building fire alarm system.

C. Manufacturer Qualification: Company specializing in manufacturing the products specified in this Section with minimum three years documented experience.

D. Design system under direct supervision of a California licensed professional engineer experienced in design of this work.

E. Emergency telephones shall be located within two feet of abort switch in accordance with Section 27 30 01, Telephone Systems.

1.10 REGULATORY REQUIREMENTS

A. Conform to applicable code for system design, fabrication, and installation.

B. Conform to NFPA 70 and NFPA 72 code for electrical wiring and wiring devices.

C. Provide certification of inspection approval of fire protection system by authority having jurisdiction.

D. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., and acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.

1.11 DELIVERY, STORAGE, AND PROTECTION

A. Refer to Section 01 60 00, Product Requirements, for requirements. Transport, handle, store, and protect products.

B. Accept materials and components on site in shipping containers. Inspect for damage.

C. Delivery and store equipment in shipping containers with labeling in place. Deliver fire-extinguishing agent in approved containers.

1.12 MAINTENANCE SERVICE

A. Refer to Section 01 77 00, Closeout Procedures, for requirements.

B. Conduct inspections six months and 12 months from date of Substantial Completion to verify proper operation of system and to check agent container weight and pressure. Include a thorough check of controls, detection and alarm systems.

C. Submit documents, certifying satisfactory system conditions. Include manufacturer’s certificate of acceptance of Inspector’s qualifications.

1.13 SITE CONDITIONS

A. Inspect surfaces and structures where the system components will be anchored or fastened before the work of this Section begins. Determine that surfaces and structures are capable of supporting the system components and their weight.

B. Coordinate the installation of the system with the building alarm and detection system and other systems and components, pipes, and conduits, so as to avoid conflicts of space and installation.

PART 2 – PRODUCTS

2.01 ALARM OPERATION DESCRIPTION

A. Alarm Phase I: One hundred percent smoke density at any sensor shall trigger or activate equipment functions as follows:

1. Annunciate the device status and its location at the system control panel;

2. Cause a pre-alarm bell within the protected zone;

3. Send a pre-alarm signal via dry contact closure to the building fire alarm control panel, a supervisory alarm to the building fire alarm control unit, and a supervisory alarm to OCC, provided under Section 28 31 00, Fire Detection and Alarm System; and

4. Record the event in the system control panel's nonvolatile RAM memory buffer for post event recall and analysis.

B. Alarm Phase II: One hundred percent smoke density at any second sensor within the same protected area shall trigger or activate equipment functions as follows:

1. Annunciate the device status and its location at the system control panel.

2. Shut down air conditioning system and close dampers.

3. Cause a pre-discharge audio and visual alarm (horn) to fast modulate within the protected zone.

4. Send a pre-discharge signal via dry contact closure to the building fire alarm control panel, and a supervisory alarm to OCC, provided under Section 28 31 00, Fire Detection and Alarm System.

5. Record the event in the system control panel's nonvolatile RAM memory buffer for post event recall and analysis, and activate a thirty-second time delay.

C. Alarm Phase III: Agent Discharge:

1. After the 30-second time delay has expired the initiator shall be activated to release the fire-extinguishing agent.

2. Send discharge alarm to building fire alarm control panel and to the OCC.

3. Upon discharge, warning bell, horn and lights shall activate continuously and remain active at all entrances to the protected area.

4. Record the event in the system control panel's nonvolatile RAM memory buffer for post event recall and analysis.

D. Manual Station Operation:

1. Requirements: The system shall be capable of being actuated by manual discharge switches for the protected area. Operation of a manual discharge switch shall cause alarm devices and shutdown functions to operate immediately. Manual stations used to release agents shall require two separate and distinct operations. The manual discharge switch shall override the time delay and abort capabilities of the system. Manual discharge switches shall be provided in the protected area at all of the exits. Each manual station shall be addressable and activation of these devices shall provide custom information at the building fire alarm control panel.

2. Pull Stations: Surface housing fitted with double action control fitted with “push-in” tab and “pull-down” lever that locks in position after releasing spring-loaded contact, for mounting on electrical outlet box. Refer to NFPA 72 for manually actuated alarm-initiating devices requirements.

3. Labeling: Locate engraved label adjacent to each manual pull station indicating area protected, and that actuation will cause discharge of fire extinguishing agent.

2.02 TROUBLE OPERATION DESCRIPTION

A. Trouble Conditions: The fire detection system shall provide the following sequence of operation for any trouble condition:

1. Display a custom message identifying the device in trouble.

2. Record the event in the system control panel’s nonvolatile RAM memory buffer for post event recall and analysis.

3. Send a trouble signal via dry contact closure to the building fire alarm control panel provided in accordance with Section 28 31 00, Fire Detection and Alarm System.

2.03 MATERIALS AND EQUIPMENT

A. General Requirements:

1. Piping and bracing shall be installed in accordance with Section 20 10 13, Common Materials and Methods for Facility Services – Fire Suppression, Plumbing and HVAC. Equipment and accessories furnished hereunder shall be standard components of a specified manufacturer. Catalog numbers and model designations shall indicate design, quality, and type of material as well as required operating characteristics.

2. Field fabricated equipment not supplied by the manufacturer will not be accepted unless approved by the Engineer.

3. Locks for cabinets shall be keyed alike.

B. Control and Supervisory Systems:

1. System Control Panel: (Red in color)

   a. The system control panel shall be red in color, and shall process all input signals, sequence the levels of alarms, and provide outputs to the extinguishing agent storage containers. Auxiliary outputs and dry contacts shall be available to shut down fans, activate dampers, contact other agencies, or annunciate to remote devices. The system shall have standby batteries and charger for continuous operation of detection, alarm, actuation, and supervision function to provide a minimum of 24 hours of emergency power. The system control panel shall provide for either a Style “D” or a Style “B” (allowing T-Tapping) as defined in NFPA 72, type wiring and shall utilize initiating devices connected in parallel to provide automatic battery switch-over upon failure of primary power supply.

   b. The system control panel shall utilize parallel agent release modules as a method of discharging the agent. The operation of a discharge signal shall immediately cause the appropriate agent release modules to activate and release agent. The initiator circuit shall be a parallel Style “D” circuit. Any system utilizing series initiators, series solenoids or mechanically activated solenoids is unacceptable. All initiator wiring shall be fully supervised.

2. Central Control Module (CCM): This module shall control, supervise, and continuously monitor the entire system through the use of an industrial grade 64-bit micro controller. This module shall include a backlit liquid crystal display (LCD) with minimum 200 alphanumeric characters that provide individual custom messages associated with every addressable device in the system. The CCM shall include touch membrane switches for each of the following:

   a. Location: Display a 100-character custom message associated with the individually addressable devices reporting to the CCM or a manufacturer-specified message for devices (i.e. door holders, air conditioning units) supervised and controlled by the CCM.

   b. Next Trouble: Displays the chronological sequence of individual addressable devices in trouble reporting to the CCM or a manufacturer-specified message for devices supervised and controlled by the CCM.

   c. Next Alarm: Displays the chronological sequence of individual addressable devices in alarm reporting to the CCM.

   d. History Buffer: The CCM shall contain a 256-event nonvolatile history buffer. This history shall be retrieved by downloading the information through an internal RS232 port, and USB port to a personal computer and printer without having to purchase additional software.

   e. Field Programming: This system shall be fully field programmable and shall not require factory assistance for reconfiguration of any kind.

f. Expansion Capability: To allow for future expansions, the central control module shall be capable of connecting a minimum of 1,016 individual addresses.

g. Approved as alarm and releasing device, with solid-state internal circuitry enclosed in NEMA ICS 6, Type 1 cabinet.

h. Provide supervision to NFPA 72, Class A of the following circuits for wire break or ground faults:

1) Zone detection loops.

2) Remote manual discharge stations.

3) Suppression system solenoid valves.

4) Power supply and circuit wiring and fuse.

5) Battery interconnecting wires and fuse.

6) Alarm in abort mode.

i. Equip panel with following standard features:

1) Visual and audible annunciation of trouble or alarm signals.

2) Panel reset switch.

3) Trouble alarm silence switch with ring back feature.

4) Single Zone Detection: Cross zone (optional).

5) Battery test meter and switch.

6) Manual discharge switch.

7) Deadman abort switch.

8) Programmable timers for pre-discharge and discharge, 0-60 second cycle.

9) Isolated relay contactors for external alarm or equipment and ventilation shutdown.

10) Relay contactors for general trouble signal.

11) Relay contactor activated by detector zone board in alarm or trouble mode.

3. Operating Sequence:

a. Actuation of one detector in either zone circuit:

1) Illuminate zone indicator.

2) Energize alarm bell.

3) Shut down air-conditioning system and close dampers.

4) Close doors to area.

5) Signal building fire alarm system via dry contact.

b. Actuation of second detector on second zone circuit:

1) Illuminate zone indicator.

2) Energize alarm horn.

3) Shut down power to protected equipment.

4) Actuate time delay for up to (30) (60) seconds.

5) Release extinguishing agent into protected area.

6) If abort switch is engaged, delay release.

7) Upon abort switch disengagement release extinguishing agent unless system cleared and reset.

8) Signal building fire alarm system via day contact closure.

c. Discharge of Extinguishing Agent:

1) Sounds alarm bells and horns.

2) Operates strobes.

d. Temperature Detection:

1) Lower Temperature: Illuminate indicator and energize (bell) (horn).

2) Higher Temperature: Shut down power to protected equipment.

4. Manual Discharge Station: Manual discharge stations shall have a dual action release configuration to prevent accidental system discharge. The legend on the front of the station shall read “Agent-Release”. These stations shall be located at emergency fire exits. A contact monitor module will be included with each station to give it a specific address (location) through the CCM.

5. System Abort Switch: The switch shall be a momentary deadman-type, that when depressed, interrupts the automatic sequence of the control system and prevents agent discharge. Each switch shall be permanently labeled “System Abort”. These stations shall be located at emergency fire exits. A contact monitor module shall be included with each switch to give it a specific address (location) through the CCM.

6. Verified Detection Sensors:

a. The photoelectric sensors shall be spaced and located, in accordance with the manufacturer’s specifications and with the guidelines of NFPA 72. Detector coverage shall not be greater than 250 square feet per detector.

b. The system control panel shall provide the command and interrogation signals that confirm an alarm by comparing (with consecutive multiple passes of the “interrogation window”) sensor information with stored data on fire conditions. The analog or addressable photoelectric sensor shall provide true linear analog data to the CCM in order for the CCM to differentiate between higher and lower values of smoke density and to establish a working range of sensitivity levels unique to the particular environment. Adjustments needed for sensor sensitivity to meet ambient conditions shall have a minimum of 12 levels of adjustment.

c. The system shall have the capacity to automatically conduct a weekly functional test of each sensor, that is accomplished by means of a test LED fitted within each sensor. When automatically activated by the control panel this test LED shall produce an infrared signal level directly equivalent to that reflected by a given percentage of smoke entering the chamber. Any sensor not responding to its preset limits shall be automatically readjusted to a programmed level of sensitivity.

7. Alarm Signal Outputs:

a. Outputs shall be provided from the system control panel for interface with building fire alarm control panel.

b. Audible and visual alarm horn and strobes: The alarms shall operate on 24-volt polarized DC power and allow for supervision. The alarm unit shall have a minimum sound level of 97 decibels at ten feet. All strobes including both in the protected room and outside room, shall be capable of 100 candelas.

C. Fire Suppression Agent:

1. The agent shall be either fluoroketone, Novec1230 (FK-5-1-12) or equal, or a heptafluoropropane, FM-200 (HFC-227ea) or equal. The physical and chemical properties shall conform with the requirements of NFPA 2001.

2. The agent shall be stored in containers, super-pressurized with nitrogen to a maximum total pressure level at 70 degrees Fahrenheit of either 360 psig or 500 psig.

Higher-pressure agents will not be accepted. Agents stored at pressure higher than 360 psig shall be contained in a safe manner and approved by the Engineer.

3. The agent shall have the following characteristics:

a. Ozone depletion potential of zero;

b. Atmospheric lifetime less than 50 years; and

c. 4-hour LC_{50} > 788,696 ppm

D. Agent Storage and Distribution Components:

1. Agent Storage Containers:

a. Standard model and size for ease or replacement and addition. Design, fabricate, certify, and stamp cylinders in accordance with ASME Section VIII.

b. The supply area of agent shall be central storage by design. The storage vessels shall be capable of being refilled in the field and checked for liquid level without the aid of scales or other special tools.

c. The supply shall be located as indicated, so that proper hydraulic agent distribution is achieved. Agent storage containers shall be floor mounted and shall include bracket assemblies designed to withstand 1000 pounds thrust for ten seconds. Floor space is limited, therefore, alternatives requiring more floor space will not be considered.

d. The storage containers shall be actuated by means of an electronic initiator. Each container shall be actuated individually. Master and slave solenoid configurations will not be considered.

e. Identification: Permanent plate, specifying agent, tare and gross weight, pound of fire extinguishing agent, and pressurization level, installed so that plate is visible and readable.

f. Cylinder valves: Heavy duty forged brass, incorporating safety release pressure operated manual control, solenoid discharge valve, and pressure gage. Provide solenoid pilot valves for each cylinder or bank of cylinders.

g. Manifold: Provide for systems with more than one cylinder with rack to secure each cylinder and check valves between each cylinder discharge and manifold.

h. The container and valve shall be capable of releasing the agent as fast as possible and shall not exceed ten seconds.

i. A nameplate indicating the manufacturer's name and part number, agent fill weight, and total charged weight shall be permanently bonded to each container.

j. Safety Release: Equip cylinder with frangible disk safety device.

k. The release valve shall accommodate a "straight through" vertical discharge with no directional changes for maximum discharge efficiency and safety. The releasing valve shall contain a "fast-acting" scored, non-fragmenting rupture membrane, which will burst when the pyrotechnic initiator is activated via an electric signal from the control panel.

2. Actuator: Release of the agent shall be accomplished by an electrical signal from the system control panel in conjunction with a specifically designed agent release module. Systems that employ more than one cylinder shall have all electric initiators connected in parallel.

3. Low Pressure Switch:

   a. The agent storage container shall be equipped with a low-pressure switch to indicate a loss of container pressure. A decrease in pressure from 360 psi to 275/272 psi will cause the normally closed contact to open, thereby indicating a trouble condition.

   b. Low pressure switch shall be monitored by the system control panel and shall provide a specific indication of cylinder low pressure.

4. Liquid Level Indicator: Tanks holding in excess of 60 pounds of agent shall contain a liquid level indicator to monitor vessel contents, in addition to the low-pressure switch.

5. Discharge Nozzles:

    a. Nozzles shall distribute the agent throughout the protected area. Single nozzle shall not discharge more than 250 pounds of agent.

    b. The nozzles shall utilize a 180 or 360-degree pattern and shall be designed to direct the discharge of agent parallel to the ceiling, thus minimizing the possibility of disturbance to objects within the room.

    c. Construction: One-piece brass or aluminum nozzle with textured finish with female pipe thread integral on body. Direct discharge parallel to ceiling.

    d. Identification: Permanently mark nozzles to show equivalent single orifices diameter.

2.04 SIGNS AND IDENTIFICATION

A. Provide signs and identification as specified in Section 20 40 13, Identification for Facility Services, and in conformance with NFPA 2001.

B. Provide signs and identification to each valve required to be identified.

C. Provide engraved nameplates for all manual discharge stations and abort switch locations to indicate their function. All alarm devices shall have similar identification plates.

D. Each entrance door shall include a caution placard indicating that the area is being protected by a clean agent fire suppression system. Where placards and signs are located outdoors, they shall be weather and UV resistant.

2.05 PIPE, FITTINGS, WIRE, AND CONDUIT

A. Pipe and Pipe Fittings:

1. Pipe and pipefittings shall conform with the requirements of NFPA 2001. Provide pipe couplers and fittings rated greater than 600 psig operating pressure.

2. The method of joining pipe shall conform with applicable requirements of NFPA 2001.

3. Hangers and bracketing shall conform with seismic zone 4 requirements.

B. Wire and Conduit:

1. Wire: No. 14 awg copper wire conforming with the requirements of Section 26 05 24, Low and Medium Voltage Wires and Cables, with insulation rating of 300 volts and temperature rating of 105 degrees Celsius. Provide power limited fire protective signaling cables conforming with the California Electrical Code, Articles 725 and 760, Type FPLR.

    a. Unavoidable splices shall be crimp-connected. Wire nuts will not be accepted.

2. Conduit: Galvanized rigid steel conduit, fittings, and accessories conforming to the requirements of Section 20 50 13, Raceways for Facility Services.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Installation Standards: Comply with applicable requirements of the NFPA 2001 and the California Electrical Code.

B. System Installation Requirements: The fire suppression system shall be installed by the manufacturer or its authorized representative as indicated and in accordance with the approved Shop Drawings and the manufacturer's installation instructions and recommendations.

C. Electrical Wiring:

1. Wiring shall be installed in galvanized rigid steel conduit, except that galvanized steel flexible conduit may be used for short runs where necessary for movement of devices.

2. Wiring shall be installed to conform with the requirements of the California Electrical Code, Article 725B for Class 1 Signal Systems, except as otherwise permitted for limited energy circuits, as specified in NFPA 72.

D. Securely support piping (in accordance with ASME B31.1) with allowance for fire-extinguishing agent thrust forces; thermal expansion and contraction; and longitudinal and lateral movement.

E. Use grooved mechanical couplings and fasteners only in accessible locations. Roll groove piping only.

F. Install unions downstream of valves and at equipment or apparatus connections.

G. Prepare pipe, fittings, supports, and accessories for finish painting, in accordance with Section 09 91 00, Painting.

H. Identify in accordance with NFPA 2001 requirements. Refer to Section 20 40 13, Identification for Facility Services. Place directional arrows and system labels wherever piping changes direction and minimum 20 feet (6 m) on straight runs.

I. Secure cylinders as indicated on Drawings. (Where manifolded, mount and support by rack as indicated. For each system provide same size cylinders containing equal amounts of liquid).

J. In rooms with suspended ceiling tiles, clip or retain tiles within 4-foot (1.2 m) radius of the nozzles to prevent lifting during discharge.

K. Install wiring in accordance with Section 26 05 24, Low and Medium Voltage Wire and Cables, requirements.

L. Make final connections between equipment and system wiring under direct supervision of factory trained representative of manufacturer.

M. Install engraved plastic instruction plate or permanently bonded label, detailing emergency procedures, at control panel and at each manual discharge and abort switch location. At control panel identify control logic units, contacts, and major circuits with permanent nameplates.

N. At hazard area walls pack space between pipe, pipe sleeve or surface penetration with mineral fiber with elastomer caulk to depth 1/2 inch (13 mm). Provide escutcheons where exposed piping passes through walls, floors, and ceilings. Seal pipe penetrations of fire separations. Refer to Section 07 90 00, Joint Protection.

O. Locate discharge nozzle approximately six inches (150 mm) above or below wall header or ceiling level and six inches (150 mm) below raised floors. Avoid interference with other piping and equipment.

P. Locate remote manual releases at one or more doors to protect area where indicated. Locate deadman abort switch.

Q. Locate strobe units at all points of entrance to protected area.

R. Locate abort station at all points of exit from protected area.

S. Ream pipe and tube ends. Remove burrs. (Bevel plain end ferrous pipe). Remove scale and dirt on inside and outside before assembly. Blow out pipe before nozzles or discharge devices are installed.

T. Route piping in orderly manner, concealed, plumb and parallel to building structure, and maintain gradient. Install piping to conserve building space, and not interfere with use of space and other work.

3.02 PAINTING

A. Except where indicated otherwise, piping systems shall not be painted. Where pipes are indicated to be painted, prepare pipe in accordance with Section 09 91 00, Painting. Provide protective covering to keep paint away from the discharge nozzles. Protective covering shall be removed at completion under Section 09 91 00, Painting.

3.03 IDENTIFICATION

A. Install signs and identification in accordance with the requirements of Section 20 40 13, Identification for Facility Services. Where signage and identification are located outdoors, moisture and UV resistant materials shall be used.

3.04 TESTS

A. System Tests: Tests shall demonstrate that the operation and installation requirements of this specification have been met. Submit certified copies of tests as specified in Article 1.06.G herein.

B. Functional Tests: Tests shall demonstrate that the entire control system functions as designed. All circuits shall be tested including automatic discharge, manual discharge, and equipment shutdown and alarm devices. In addition, supervision of each circuit shall be tested.

C. Design Review Test: Take field measurements of the room, and field calculate the amount of clean agent required to reach the design criteria, and match against the contents of the clean agent storage containers.

D. Pressurization Test: Conduct a door fan test to determine the overall containment capacity of the clean agent protected area, and equivalent leakage area of the room. The calibrated fan unit shall be used to pressurize or depressurize the area with all air conditioning shutdown and dampers closed, and monitor airflow versus pressure data. The results shall be used to calculate a pass or non-pass conclusion. A manufacturer-approved testing unit and program shall be used for this test.

E. Piping Test Review: Make a field verification of the piping network and match against the drawing flow calculations. All significant variations will require recalculation of the piping system.

1. A distribution piping and valve, prior to nozzle installation pressurization test shall be conducted that requires 150 psi to be held for ten minutes with no more than ten percent pressure drop. Inspect joints using soap water solution or halide torch or lamp, replace and retest.

2. A “puff” test using dry nitrogen shall be conducted. Caps shall be placed over all discharge nozzles and adequate pressure shall be supplied to demonstrate that all of the caps will blow off indicating that the pipes are free of obstructions.

3. Upon completion of installation provide final checkout inspection by factory-trained representative of manufacturer to ascertain proper system operation. Leave system in a fully commissioned and automatic readiness state with circuitry energized and supervised.

4. Submit original copies of tests, indicating that factory trained technical representatives of the manufacturer have inspected and tested systems and are satisfied with methods of installation, connections and operations.

5. After successful testing, de-pressurize the system and remove nozzle caps without moving pipes, and install discharge nozzles without moving pipe assembly.

3.05 TRAINING AND INSPECTIONS

A. Training Requirements: Provide complete system operation training of at least four hours for six of the District's maintenance personnel in accordance with Section 01 79 00, Demonstration and Training.

B. Fire Suppression System Inspections:

1. Provide two inspections of the system during the one-year warranty period. The first inspection shall be six months after system acceptance and the second after 12 months. Inspections shall include the determination of agent container weight and pressure and that the mechanical systems are in proper working order.

2. Inspections shall also include a complete checkout of the control and alarm system and test, if possible that all interlocking systems are functioning properly.

3. Documents certifying satisfactory system conditions shall be submitted upon completion of each inspection.

END OF SECTION 21 22 00

SECTION 22 11 01

WATER DISTRIBUTION

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Buried pipe and fittings.

B. Above ground pipe and fittings.

C. Joints and jointing materials.

D. Valves.

E. Piping accessories.

1.02 RELATED SECTIONS

A. Section 01 33 00, Submittal Procedures.

B. Section 01 33 23, Shop Drawings, Product Data, and Samples.

C. Section 01 45 00, Quality Control.

D. Section 01 78 23, Operation and Maintenance Data.

E. Section 09 91 00, Painting.

F. Section 20 10 13, Common Materials and Method for Facility Services.

G. Section 20 20 13, Pipe Sleeves, Supports, and Anchors for Facility Services.

H. Section 20 40 13, Identification for Facility Services.

I. Section 33 05 28, Trenching and Backfilling for Utilities.

J. Section 33 11 00, Water Utility Distribution Piping.

1.03 MEASUREMENT AND PAYMENT

A. Separate measurement or payment will not be made for the work required under this Section. All costs in connection with the Work specified herein will be considered to be included or incidental to the Work of this Contract.

1.04 REFERENCES

1. ASTM B42 Seamless Copper Pipe.

2. ASTM B43 Seamless Red Brass Pipe.

3. ASTM B68	Seamless Copper Tube (ASTM B68M – Seamless Copper Tube [Metric]).
4. ASTM B75	Seamless Copper Tube (ASTM B75M – Seamless Copper Tube [Metric]).
5. ASTM B251	Wrought Seamless Copper and Copper-Alloy Tube (ASTM B251M-Wrought Seamless Copper and Copper-Alloy Tube [Metric]).
6. ASTM B302	Threadless Copper Pipe (TP).
7. ASTM C443	Joints for Circular Concrete Sewer and Culvert Pip, Using Rubber Gaskets (ASTM C443M – Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets [Metric]).
8. ASTM C564	Rubber Gaskets for Cast Iron Soil Pipe and Fittings.
9. ASTM D1785	Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80 and 120.
10. ASTM D2235	Solvent Cement for Acrylonitrile – Butadiene – Styrene (ABS) Plastic Pipe and Fittings.
11. ASTM D2239	Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter.
12. ASTM D2241	Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series).
13. ASTM D2447	Polyethylene (PE) Plastic Pipe Schedules 40 and 80, Based on Outside Diameter.
14. ASTM D2466	Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
15. ASTM D2564	Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings.
16. ASTM D2609	Plastic Insert Fittings for Polyethylene (PE) Plastic pipe.
17. ASTM D2661	Acrylonitrile – Butadiene – Styrene (ABS) Schedule 40 Plastic Drain, Waste, and Vent Pipe and Fittings.
18. ASTM D2662	Polybutylene (PB) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter.
19. ASTM D2665	Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings.
20. ASTM D2666	Polybutylene (PB) Plastic Tubing.

21. ASTM C14 Concrete Sewer, Storm Drain, and Culvert Pipe (ASTM C14M – Concrete Sewer, Storm Drain, and Culvert Pipe [Metric].

22. ASTM C443 Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets (ASTM C443M – Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets [Metric].

23. ASTM C564 Rubber Gaskets for Cast Iron Soil pipe and Fittings.

24. ASTM C1053 Borosilicate Glass Pipe and fittings for Drain, Waste, and Vent (DWV) Applications.

25. ASTM D1785 Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80 and 120.

26. ASTM D2235 Solvent Cement for Acrylonitrile – Butadiene – Styrene (ABS) Plastic Pipe and Fittings.

27. ASTM D2665 Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings.

28. ASTM D2666 Polybutylene (PB) Plastic Tubing.

29. ASTM D2683 Socket-Type Polyethylene Fillings for Outside Diameter-Controlled Polyethylene Pipe.

30. ASTM D2729 Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings.

31. CISPI 301 Cast Iron Soil Pipe and Fittings for Hubless Cast Iron Sanitary Systems.

32. CISPI 310 Joints for Hubless Cast Iron Sanitary Systems.

33. American Water Works Association (AWWA):

    a. AWWA C651 Disinfecting Water Mains

34. Manufacturers Standardization Society (MSS):

    a. MSS SP-70 Cast Iron Gate Valves, Flanged and Threaded Ends

    b. MSS SP-80 Bronze Gate, Globe, Angle and Check Valves

35. Plumbing and Drainage Institute (PDI):

    a. PDI WH 201 Water Hammer Arrester Standard

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit Shop Drawings showing piping layout and pipe sizes, types valve sizes and locations of valves, shock absorbers, and escutcheon plates.

C. Product Data: Submit manufacturer's product data for specified materials and equipment.

D. Operation and Maintenance Data: Submit operation and maintenance data for the equipment provided in accordance with Section 01 78 23, Operation and Maintenance Data.

1.06 SITE CONDITIONS

A. Evacuations in which products will be buried shall be dry. Inspect surfaces and structures to, and on, which the water supply system will be installed before the work of this Section begins. Provide surfaces and structures capable of supporting the system and its weight.

B. Coordinate the installation of the water supply system with other building systems and components so as to avoid conflicts of installation. Drawings are diagrammatic and not necessarily to scale. The Contractor shall not scale drawings for exact locations of installation of pipelines, valves, and equipment.

PART 2 – PRODUCTS

2.01 BURIED OR UNDERGROUND PIPE AND FITTINGS

A. Requirements: Provide the types, sizes, and configurations of pipe, fittings, and miscellaneous materials and accessories as indicated.

B. Pipe and Fittings:

1. Three Inches and Smaller: Provide Class H as specified in Section 20 10 13, Common Materials and Methods for Facility Services – Fire Suppression, Plumbing and HVAC.

2. Four Inches and Larger: Pipe and Fittings shall be fusible and conform to Class K and class T as specified in Section 20 10 13, Common Materials and Methods for Facility Services – Fire Suppression, Plumbing and HVAC.

2.02 ABOVE GROUND OR EXPOSED PIPE AND FITTINGS

A. Requirements: Provide types, sizes, and configurations of pipe and fittings as indicated.

B. Pipe and Fittings:

1. Two and one-half inches and smaller: Provide Class E as specified in Section 20 10 13, Common Materials and Methods for Facility Services – Fire Suppression, Plumbing and HVAC.

2. Three inches and larger: Provide Class W as specified in Section 20 10 13, Common Materials and Methods for Facility Services – Fire Suppression, Plumbing and HVAC.

3. Union for connecting steel pipe to copper tubing and tube shall be dielectric union type.

2.03 JOINTS AND JOINTING MATERIALS

A. Provide flanges, bolts, nuts, and gaskets as specified in Section 20 10 13, Common Materials and Methods for Facility Services – Fire Suppression, Plumbing and HVAC.

B. Provide insulating joints, in accordance with Section 20 10 13, Common Materials and Methods for Facility Services – Fire Suppression, Plumbing and HVAC, on metallic water lines where indicated.

C. Provide expansion joints, in accordance with Section 20 10 13, Common Materials and Methods for Facility Services – Fire Suppression, Plumbing and HVAC.

2.04 VALVES

A. Requirements: Valves shall be of sizes and types indicated. Valves two inches and smaller shall have threaded fittings and connections, and valves two and one half inches and larger shall have flanged ends.

B. Refer to Section 20 10 13, Common Materials and Methods for Facility Services – Fire Suppression, Plumbing and HVAC, for gate valves, globe valves, ball valves, check valves, butterfly valves, air release valves, and gages.

C. Pressure Reducing Valves: MSS SP-80 valves two inches and smaller shall be all bronze construction meeting requirements of MSS SP-80. MSS-SP-85 valves two and one half inches and larger shall be all cast iron construction meeting requirements of MSS SP-70. Valves two and one half inches and smaller shall have threaded connections. Valves three inches and larger shall have flanged connections. Valves shall be stainless steel spring-loaded, single-seated, and suitable for tight shutoff under dead-end conditions. Provide with renewable stainless steel seat, nylon inserted diaphragm, and bolted spring chamber. Valves shall be rated for 300 psi working pressure, adjustable from 25 to 75 psi, factory set at 50 psi. Pressure gauges (or gauge ports) shall be installed upstream and downstream of the pressure-reducing valve.

D. Relief Valves:

1. AGA Z21-22 pressure and temperature relief valves shall be AGA design certified, ASME listed and rated, with bronze body, brass trim, stainless steel spring and silicone rubber seat disc. Pressure and temperature valves shall be installed on all water heaters and hot water storage tanks, rated for heating capacity of water heater.

2. Valves shall be ASME rated for intended service, and shall be single-seated, bronze body and trim, stainless steel spring, adjusting screw with cap and threaded connections for two and one half inches and smaller valves, and flanged connections for three inches and larger valves.

E. Backflow Preventer: Provide device, that is approved by the water utility company. As a minimum, backflow preventer shall be a reduced pressure principle assembly. Backflow preventer shall be suitable for 175 psig operating pressure and 140 degrees Fahrenheit operating temperature and shall be of bronze construction with screwed inlet and outlet for two inches and smaller sizes, and cast iron, including the check valves, epoxy-coated construction with 150 pound flanged inlet and outlet for two and a half inches and larger sizes.

2.05 PIPING ACCESSORIES

A. Provide piping accessories of types and sizes indicated.

B. Provide escutcheons as specified in Section 20 20 13, Pipe Sleeves, Supports, and Anchors for Facility Services

C. Provide shock absorbers of either bellows or diaphragm type, conforming to PDI WH 201, of size and location indicated.

D. Wall sleeves and seals shall be in accordance with Section 20 20 13, Pipe Sleeves, Supports, and Anchors for Facility Services

PART 3 – EXECUTION

3.01 INSTALLATION

A. Excavating and backfilling, including bedding and compacting requirements, shall conform to Section 33 05 28, Trenching and Backfilling for Utilities.

B. Provide concrete thrust blocks for elbows, tees, valves, and appurtenances on buried piping. Thrust blocks shall be constructed as indicated. Do not install pressure piping under building slabs, footings or foundations. Do not install pressure piping under any part of a building. Do not encase pressure piping.

C. Install piping true to line and grade, supported and guided to ensure alignment under all conditions. Installed piping shall clear obstructions, preserve headroom, and keep openings and passageways clear.

D. Valves shall be accessible for operation and servicing. Valves located in furred spaces shall be accessible through access panels or access doors. Valves shall be installed as indicated, and shall not be installed having stems located below the horizontal position.

E. Install unions at each connection to valves, equipment, and tanks. Soldered-to-threaded connections shall be made-up with male thread-to-solder adapters.

F. After installation of pipes, ends of pipes shall be either capped or plugged. No piping shall be buried, furred in, or concealed before being inspected and tested.

G. Install wall sleeves and insulating seals in accordance with Section 20 20 13, Pipe Sleeves, Supports, and Anchors for Facility Services.

H. Provide access panels in accordance with Section 20 10 13, Common Materials and Methods for Facility Services – Fire Suppression, Plumbing and HVAC.

3.02 TESTING

A. Test potable water system and hot water system, each hydrostatically in sections, to a pressure of at least 150 psi for not less than 15 minutes witnessed by the Engineer. Pressure-test pipe before burial and concealment. Repair leaks and retest the system until the system is leak free. Use testing instruments calibrated by a qualified laboratory in accordance with Section 01 45 00, Quality Control. Test sequence shall be as follows:

1. Lines shall be fully flushed.

2. Lines shall be hydrostatically tested.

3. Lines shall be fully flushed.

4. Lines shall be fully disinfected.

3.03 SYSTEM DISINFECTION

A. Before final acceptance of the water supply system, each section of the new line shall be disinfected in accordance with AWWA C651. One of the following sources of disinfectant shall be used:

1. Mixture of water and chlorine gas;

2. Direct application of chlorine;

3. Mixture of water and calcium hypochlorite; or

4. Mixture of water and calcium chloride.

B. Before disinfecting, flush the line thoroughly to remove dirt and extraneous materials. Clean each section of the line between valves independently.

C. Retain the disinfectant solution in the pipe for at least 24 hours. Following this sterilization period, the residual chlorine content at the ends of the section and at other representative points shall be not less than five parts per million. Then, the line shall be drained and thoroughly flushed with water until the residual chlorine content is similar to that obtained from the distribution system.

D. Take water samples and test in accordance with AWWA C651.

3.04 IDENTIFICATION

A. Comply with the requirements of Section 20 40 13, Identification for Facility Services.

3.05 PAINTING

A. Except where indicated, piping systems shall not be painted. Where pipes are indicated to be painted, as exposed pipe in finished rooms, prepare and paint pipe in accordance with Section 09 91 00, Painting.

END OF SECTION 22 11 01

SECTION 22 13 01

SANITARY SEWERAGE

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Buried sewer pipe and fittings.

B. Exposed soil, waste, drain, and vent piping.

C. Valves.

D. Floor drains.

E. Gutter and trench drains.

F. Battery room floor drains.

G. Cleanouts.

H. Piping specialties.

I. Flashings.

J. Escutcheons.

K. Neutralizing sumps.

L. Sewage ejectors.

M. Interceptors and tanks.

1.02 RELATED SECTIONS

A. Section 01 33 00, Submittal Procedures.

B. Section 01 33 23, Shop Drawings, Product Data, and Samples.

C. Section 01 45 00, Quality Control.

D. Section 01 78 23, Operation and Maintenance Data.

E. Section 09 91 00, Painting.

F. Section 20 10 13, Common Materials and Method for Facility Services.

G. Section 20 20 13, Pipe Sleeves, Supports, and Anchors for Facility Services.

H. Section 20 40 13, Identification for Facility Services.

I. Section 22 14 29, Sump Pumps.

J. Section 22 40 00, Plumbing Fixtures.

K. Section 33 05 28, Trenching and Backfilling for Utilities.

L. Section 33 31 00, Sanitary Utility Sewerage Piping.

1.03 MEASUREMENT AND PAYMENT

A. Separate measurement or payment will not be made for the work required under this Section. Costs in connection with the Work specified herein will be considered to be included or incidental to the Work of this Contract.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM A48/A48M Specification for Gray Iron Castings.
2. ASTM A74 Specification for Cast Iron Soil Pipe and Fittings
3. ASTM D4021 Specification for Glass-Fiber-Reinforced Polyester Underground Petroleum Storage Tanks
4. ASTM C14 Concrete Sewer, Storm Drain, and Culvert Pipe (ASTM C14M Concrete Sewer, Storm Drain, and Culvert Pipe [Metric]).
5. ASTM C443 Joints for Circular Concrete Sewer and Culvert Pip, Using Rubber Gaskets (ASTM C443M – Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets [Metric]).
6. ASTM C564 Rubber Gaskets for Cast Iron Soil Pipe and Fittings.
7. ASTM D1785 Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
8. ASTM D2235 Solvent Cement for Acrylonitrile – Butadiene – Sryrene (ABS) Plastic Pipe and Fittings.
9. ASTM D2564 Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings.
10. ASTM D2609 Plastic Insert Fittings for Polyethylene (PE) Plastic Pipe.
11. ASTM D2661 Acrylonitrile – Butadiene – Styrene (ABS) Schedule 40 Plastic Drain, Waste, and Vent Pipe and Fittings.
12. ASTM D2662 Polybutylene (PB) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter.

13. ASTM D2665 Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings.

14. ASTM D2666 Polybutylene (PB) Plastic Tubing.

15. ASTM D2683 Socket-Type Polyethylene Fillings for Outside Diameter-Controlled Polyethylene Pipe.

16. ASTM D2729 Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings.

17. ASTM D2751 Acrylonitrile – Butadiene – Styrene (ABS) Sewer Pipe and Fittings.

18. ASTM D3034 Type PSM Poly (Vinyl Chloride) Sewer Pipe and Fittings.

19. CISPI 301 Cast Iron Soil Pipe and Fittings for Hubless Cast Iron Sanitary Systems

20. CISPI 310 Joints for Hubless Cast Iron Sanitary Systems.

B. Manufacturer's Standardization Society of Valve and Fitting industry (MSS):

1. MSS SP-70 Cast Iron Valves, Flanged and Threaded Ends

2. MSS SP-80 Bronze Gate, Globe, Angle and Check Valve

C. California Department of Transportation (Caltrans):

1. Caltrans Bridge Design Specifications, Part 3, Loads

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit Shop Drawings showing piping layouts, sizes, types, valves, drains, cleanouts, sewage structure ejector station, and air compressor assembly.

C. Product Data: Submit manufacturers' product data for specified materials and equipment.

D. Operation and Maintenance Data: Submit equipment manufacturer's printed operating and maintenance instructions in accordance with Section 01 78 23, Operation and Maintenance Data, consisting of detailed parts list, recommended spare parts list, and complete operation and maintenance procedures.

E. Test Reports: Submit certified test reports of valves and equipment, as applicable.

1.06 SITE CONDITIONS

A. Excavations shall be dry immediately before and after products are installed. Provide surfaces and structures to, and on, which sewerage products will be installed capable of supporting the products. Complete construction, which will be concealed by sewerage products before sewerage products are installed.

B. Coordinate the installation of the sanitary sewerage system with other building systems and components so as to avoid conflicts of installation. Drawings are diagrammatic and not necessarily to scale. Do not scale drawings for exact locations of installation of pipelines, valves, and equipment.

PART 2 – PRODUCTS

2.01 SEWER PIPE AND FITTING MATERIALS

A. Drain and Vent piping buried underground shall be Class D PVC as specified in Section 20 10 13, Common Materials and Methods for Facility Services, Fire Suppression, Plumbing and HVAC.

B. Drain and Vent piping above ground shall be Class B cast iron, as specified in Section 20 10 13, Common Materials and Methods for Facility Services, Fire Suppression, Plumbing and HVAC.

1. Exposed drain and vent piping installed below finished grade in crawl spaces, utility chases, basements, parking garages, or other similar locations shall be considered above ground for the purposes of drain and vent piping material selection.

2. Drain and vent piping installed below finished grade and concealed within framed walls shall be considered above ground for the purposes of drain and vent piping material selection.

C. Ejector pump discharge lines buried underground shall be Class H PVC and exposed discharge lines shall be Class C, steel pipe as specified in Section 20 10 13, Common Materials and Methods for Facility Services, Fire Suppression, Plumbing and HVAC.

D. Acid waste piping shall be Class H PVC pipe as specified in Section 20 10 13, Common Materials and Methods for Facility Services, Fire Suppression, Plumbing and HVAC.

E. Trap Primer Piping and HVAC condensate drain piping shall be Class F copper tubing as specified in Section 20 10 13, Common Materials and Methods for Facility Services, Fire Suppression, Plumbing and HVAC.

2.02 NOT USED

2.03 VALVES

A. Gate and Check Valves: Refer to Section 20 10 13, Common Materials and Methods for Facility Services, Fire Suppression, Plumbing and HVAC, for gate valves and swing check valves.

B. Backwater Valves: Provide backwater valves with cast iron bodies, hinged flaps, and seats, bolted covers, bronze trim, and flaps and seats removable through covers. Disc shall allow leakage, which will eliminate blocking of the valve by the bridging of solids on the upstream side. Flaps shall be sensitive to backflow, and capable of closing immediately upon backflow.

C. Trap Primer Unit: Provide automatic trap primer valve, copper or cast bronze, solder joint ends, with internal air gap, in-line type, complete with distribution unit.

2.04 FLOOR DRAINS

A. Provide as specified in Section 22 40 00, Plumbing Fixtures.

2.05 GUTTER AND TRENCH DRAINS

A. Provide as specified in Section 22 40 00, Plumbing Fixtures.

2.06 BATTERY ROOM FLOOR DRAIN

A. Provide as specified in Section 22 40 00, Plumbing Fixtures.

2.07 CLEANOUTS

A. Cleanouts shall be provided on all floors and throughout each facility. Cleanouts shall be of the sizes as indicated in the Contract Documents and shall be of cast iron conforming to ASTM A48/A48M, Class 25B. Cleanout maximum distance shall comply with the California Plumbing Code.

B. Floor cleanouts for parking structures shall be cast iron construction with bronze plug, vandal proof screws, and with scoriated cover and membrane clamping device. For all other facilities, the top, frame, and cover shall be nickel alloy.

C. Wall cleanouts shall be bolted, wedge type having a cover. Cover plate shall be mounted in a flanged frame, shall be stainless steel, ad shall be secured to the plug with a vandal-proof screw.

D. Exposed cleanouts shall have a raised brass head cleanout plug.

E. Grade cleanouts shall have an adjustable sleeve-type housing, a threaded brass plug with countersunk slot, and cast iron frame and cover.

F. Two-way cleanouts shall be provided at locations where track drainage drains underground.

2.08 PIPING SPECIALTIES

A. Gaskets for flanged joints shall be as specified in Section 20 10 13, Common Materials and Methods for Facility Services, Fire Suppression, Plumbing and HVAC.

B. Couplings for connecting above ground and underground piping shall be specifically designed for the purpose required with transition type gaskets.

2.09 FLASHINGS

A. Provide either soft tempered or cold rolled copper, weighing not less than 16 ounces per square foot, or sheet lead, weighing not less than four pounds per square foot.

2.10 ESCUTCHEONS

A. Provide as specified in Section 20 20 13, Pipe Sleeves, Supports and Anchors for Facility Services.

2.11 NEUTRALIZING SUMPS

A. Provide sump molded in one piece from polyethylene with NPT connections and having minimum capacity of 15 gallons or 1.33 cubic feet of usable volume.

B. The sump shall be completely filled with marble chips, and furnished complete with gasketed, bolted polyethylene cover.

2.12 SEWAGE EJECTOR

A. Provide in accordance with Section 22 14 29, Sump Pumps.

2.13 INTERCEPTORS

A. Interceptors shall be a continuous deflective type located in a conveniently accessible location on the exterior of the building, sized for providing the water quality required for safe discharge.

PART 3 – EXECUTION

3.01 PREPARATION

A. Excavations shall be free of water and extraneous material immediately before sanitary sewerage products are installed or placed. Bottoms of trenches shall have a six inch sand bed and shall be formed to support the bottom quadrant of the pipe and fittings. Should rock be encountered or should bedding material be unsuitable to support the products at indicated elevation, continue excavation to an elevation eight inches below the indicated elevation and backfill with clean sand to the indicated elevation.

B. Interior of pipe, pipe fittings, valves, drains, and cleanouts shall be cleaned of dirt and foreign substances before installation.

C. Install sleeves through walls, floors, roofs, and other structures before sewerage lines are installed. Piping shall not be installed under walls, foundations, or footings. Invert of sleeves shall be minimum six inches above the bottom of footings and foundations.

3.02 INSTALLATION

A. Excavating and backfilling, including bedding and compacting requirements, shall conform to Section 33 05 28, Trenching and Backfilling for Utilities.

B. Install products where indicated. Remove and reinstall products that are disturbed after installation. Ends of products to which future connections will be made shall be valved, plugged, or capped, and anchored.

C. Connections to existing facilities shall be made with fittings and short bends to suit the actual conditions; connect products in accordance with the product manufacturer's printed installation instructions.

D. Pipe and fittings shall be set true to line and grade before joints are made up. Angular deflections of joints shall not exceed the recommendations of the pipe and fitting manufacturer. Should the alignment require deflection of joints to be in excess of those recommended, use special bends to achieve the indicated deflection. Pipe ends and joints shall be prepared in accordance with the manufacturer's recommendations. As a minimum pipe ends shall be sanded and cleaned, fittings shall be cleaned, and solvent shall be applied to both pipe and fittings.

E. Slope horizontal soil and waste pipes a minimum two percent downward in direction of flow. Extend main vertical soil and waste stacks full size to the roof line and above as vents, except where otherwise specifically indicated. Run vent pipes in roof spaces as close as possible to the underside of the roof without forming traps in pipe, using fittings as required. If a circuit vent pipe from fixture, or line of fixtures, will be connected to a vent line serving other fixtures, the connection shall be at least 6 inches above the flood level of the highest fixture served. Grade and connect vent and branch vent pipes to drip back to the vertical stack by gravity. Support all above grade piping in accordance with 20 20 13, Pipe Sleeves, Supports, and Anchors.

F. Install wall sleeves and seals in accordance with Section 20 20 13, Pipe Sleeves, Supports, and Anchors. Sealing members shall be installed so as to provide electrical isolation between the metallic carrier pipe and all metallic components of the sleeve and seal.

G. Make changes in pipe size on soil, waste, and drain lines with reducing fittings. Changes in direction shall be with either 45-degree wyes long sweep 1/4, 1/6, 1/8 or 1/16 bends, or elbows. Short sweep fitting shall be used in venting only or as approved by the engineer.

H. Slip joints will be permitted only in fixture trap seals on the inlet side of the traps.

I. Installation of pipe and fittings shall comply with the manufacturers' recommendations. Mitering of joints for elbows and notching of straight runs of pipe for tees will not be permitted.

J. Joints in no hub waste pipe and fittings shall use full circumference, Type 316 SS compression band and screws, 12 gauge or heavier with full length neoprene gasket.

K. Tighten band and screw assemblies used in conjunction with hubless type cast iron pipe to 60 inch pounds of torque on each band screw, with a torque wrench specifically designed for the purpose.

L. Provide escutcheons at all finished surfaces where exposed piping, bare or insulated, passes through floors, walls, and ceilings. Fasten escutcheons to pipe or pipe covering.

M. Equip each fixture and piece of equipment connecting to the sanitary sewer system with a drain trap located as near fixture as possible, and no fixture shall be double trapped.

N. Provide acid proof piping in locations indicated. Install acid proof piping separate from other waste piping, and connect to neutralizing sump, then to other sanitary piping only at mains.

O. Drains:

1. Floor drains connected to sanitary sewers shall be trapped and provided with trap primers. Trap primer make up line shall have a horizontal run to the floor drain of 20 feet or less and have a continuous slope.

2. Maintain integrity of waterproof membranes where penetrated by installing flashing collar or flange so that no leakage occurs between drain and adjoining materials.

3. Position drains and neutralizing sumps so that they are readily accessible and easy to maintain.

P. Provide access panels in accordance with Section 20 10 13, Common Materials and Methods for Facility Services, Fire Suppression, Plumbing and HVAC.

Q. Interceptor and Tank Installation: Manhole covers shall be set with frame in reinforced concrete collar 48 inches minimum wide by 6 inches thick with No. 4 reinforcement 12 inches each way and finished flush with grade. Storage tanks shall be installed with antiflotation slabs and tie downs in accordance with the manufacturer’s instructions. Interceptors shall be installed on redwood sleepers or antiflotation slab in accordance manufacturer’s instructions. Both storage tanks and interceptors shall have material backfill installed to grade in accordance with the manufacturer’s instructions.

3.03 PIPE CLEANOUTS

A. Cleanouts shall be the same size as the pipe up to and including six inch pipe. Cleanouts for drainage pipe shall consist of a longsweep 1/4 bend or one or two 1/8 bends extended to the place indicated. Wall or accessible piping cleanouts shall be T pattern, 90-degree branch drainage fittings having screw plugs. Cleanouts shall

be provided at the base of each riser and shall consist of a wye pattern fitting with a screw plug.

3.04 IDENTIFICATION

A. Identification shall be as specified in Section 20 40 13, Identification for Facility Services.

3.05 FIELD QUALITY CONTROL

A. Do not cover products to be buried and do not paint products or line segments to be painted until those products have been inspected, tested, and accepted.

B. Test installed sewerage lines and equipment, with the Engineer in attendance, as follows:

1. Fill gravity sewers and soil pipe with water and allow to stand for not less than 30◦minutes without leaking; low and intermediate branches shall have been temporarily sealed. Provide test tees having cast iron screwed plugs in the vertical stacks if the sewers and soil pipe are to be tested in sections. Accomplish testing of interior lines before lines are concealed. Repair leaks and retest systems until the system exhibits no leaks. Head of water shall be not less than 10 feet.

2. Disconnect force mains from equipment, seal open ends, and fill mains with water, and hydrostatically test to a pressure of 50 psi greater than the normal pumping pressure. Maintain test pressure until the force main system has been examined for leaks. Repair leaks and retest system until no leaks are exhibited. Use testing instruments calibrated by a qualified laboratory in accordance with Section 01 45 00, Quality Control.

3. Test equipment by operation and adjustment of controls. Faulty equipment or controls shall be either repaired or replaced.

4. After hydrostatic testing and prior to backfilling or burying pipe, a plumber’s snake with camera attachment shall be run though this pipe in the presence of the engineer to confirm proper drainage and lack of construction debris. The presence of debris or rocks and any indication of dips or traps shall be corrected prior to backfilling.

3.06 PAINTING

A. Except where indicated, piping systems shall not be painted. Where pipes are indicated to be painted, as exposed piping in finished rooms, prepare pipe and paint in accordance with Section 09 91 00, Painting.

3.07 CLEANING

A. Cleaning of installed products shall consist of removing dirt and foreign material from the surfaces of products. Manufacturer’s labels shall remain intact. Rust stained

products shall either be replaced or recoated with paint, which is compatible with factory-applied coating.

3.08 REPAIR

A. Repair pipe coatings, which have become damaged during installation of pipe. Rust stained cast iron pipe and fittings shall either be replaced or recoated with paint, which is compatible with factory-applied coating.

END OF SECTION 22 13 01

SECTION 22 14 01

STORM DRAINAGE

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Embedded track drainage, buried drainage pipe and fittings.

B. Exposed and above grade drainage pipe and fittings.

C. Drains.

D. Cleanouts.

E. Manhole covers and frames.

F. Escutcheons.

G. Valves.

H. Storm drain markers.

1.02 RELATED SECTIONS

A. Section 05 50 00, Metal Fabrications.

B. Section 09 91 00, Painting.

C. Section 20 10 13, Common Materials and Method for Facility Services – Fire Suppression, Plumbing, and HVAC.

D. Section 20 20 13, Pipe Sleeves, Supports, and Anchors for Facility Services.

E. Section 20 40 13, Identification for Facility Services.

F. Section 33 05 16, Utility Structures.

G. Section 33 05 28, Trenching and Backfilling for Utilities.

H. Section 33 40 00, Storm Drainage Utilities.

1.03 MEASUREMENT AND PAYMENT

A. Separate measurement or payment will not be made for the work required under this Section. All costs in connection with the Work specified herein will be considered to be included or incidental to the Work of this Contract.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM A48/A48M Standard Specifications for Gray Iron Castings
2. ASTM A74 Standard Specifications for Cast Iron Soil Pipe and Fittings
3. ASTM C4 Standard Specifications for Clay Drain Tile and Perforated Clay Drain Tile
4. ASTM C564 Standard Specifications for Rubber Gaskets for Cast Iron Soil Pipe and Fittings
5. ASTM D2564 Standard Specifications for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings
6. ASTM D2609 Standard Specifications for Plastic Insert Fittings for Polyethylene (PE) Plastic Pipe
7. ASTM D2683 Standard Specifications for Socket-Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene Pipe and Tubing
8. CISPI 301 Standard Specifications for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications
9. CISPI 310 Standard Specifications for Coupling for Use in Connection with Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications
10. ASME A112.6.3 Floor and Trench Drains
11. ASME A112.6.4 Roof, Deck, and Balcony Drains

B. Manufacturer's Standardization Society of the Valve and Fitting Industry (MSS):

1. MSS SP70 Gray Cast Iron Gate Valves, Flanged and Threaded Ends
2. MSS SP80 Bronze Gate, Globe, Angle and Check Valves

C. California Code of Regulations (CCR), Title 24:

1. CBC Part 2, California Building Code
2. CPC Part 5, California Plumbing Code

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit Shop Drawings showing piping layouts, sizes, types, valves, drains, and cleanouts.

C. Product Data: Submit manufacturers' product data and Material Safety Data Sheet (MSDS) for specified materials and equipment.

D. Operation and Maintenance Data: Submit equipment manufacturer's printed operating and maintenance instructions in accordance with Section 01 78 23, Operation and Maintenance Data, consisting of detailed parts list, recommended spare parts list, and complete operation and maintenance procedures.

E. Test Reports: Submit certified test results and Certificates of Compliance as necessary to verify conformance with specified requirements.

1.06 SITE CONDITIONS

A. Excavations for drainage products shall be dry and stabilized before and after products to be buried are installed. Surfaces and structures to, and on, which drainage products will be installed shall be capable of supporting the products. Surfaces that will be concealed by drainage products shall be completed before drainage products are installed.

B. Prior to trenching and excavation, the Contractor shall have an OSHA designated Trenching and Excavation Competent Person survey the site and assess the conditions and soil types (Type A, B, or C soil) to determine trenching and excavation operations, methods, and procedures, and site areas and activities that may be affected by such excavations. Excavations shall proceed with the Engineer's approval.

PART 2 – PRODUCTS

2.01 EMBEDDED TRACK DRAINAGE, BURIED DRAINAGE PIPE AND FITTINGS

A. For drainage and vent piping, except as noted here in: provide pipe and fittings of sizes and configurations as indicated in the Contract Documents. Provide Class D pipe and fittings as specified in Section 20 10 13, Common Materials and Methods for Facility Services - Fire Suppression, Plumbing and HVAC, for non-pressure piping.

B. For embedded track drain: Provide Class H pipe and fittings as specified in Section 20 10 13, Common Materials and Methods for Facility Services – Fire Suppression, Plumbing and HVAC.

C. For buried applications sump pump discharge: Provide Class H pipe and fittings as specified in Section 20 10 13, Common Materials and Methods for Facility Services – Fire Suppression, Plumbing and HVAC.

2.02 EXPOSED AND ABOVE GRADE DRAINAGE PIPE AND FITTINGS

A. For drainage and vent piping: Provide Class B drainage and vent pipe and fittings as specified in Section 20 10 13, Common Materials and Methods for Facility Services – Fire Suppression, Plumbing and HVAC.

B. For sump pump discharge: Provide Class C drainage and vent pipe and fittings as specified in Section 20 10 13, Common Materials and Methods for Facility Services – Fire Suppression, Plumbing and HVAC.

2.03 DRAINS

A. Requirements: Provide the type, size, and configuration as indicated in the Contract Documents, with vandal-proof strainers and strainer fasteners, as hereinafter specified.

B. Roof Drain:

1. Assembly: ASME A112.6.4.

2. Body: Cast iron body, flashing clamp with seepage openings, and square hole grade as indicated in the Contract Documents.

3. Strainer: Removable cast iron dome.

4. Accessories: Coordinate with roofing type Membrane flange and membrane clamp with integral gravel stop. Adjustable under deck clamp. Where indicated in the Contract Documents.

   Roof sump receiver.

   Waterproofing flange.

   Controlled flow weir.

   Leveling frame.

   Adjustable extension sleeve for roof insulation.

   Perforated or slotted ballast guard extension for inverted roof.

   Perforated stainless steel ballast guard extension.

C. Parapet Drains: Cast iron body with aluminum flashing clamp collar and epoxy coated cast iron sloping grate.

D. Canopy and Cornice Drains: Cast iron body with aluminum flashing clamp collar and epoxy coated cast iron flat strainer.

E. Roof Overflow Drains: Cast iron body and clamp collar and bottom clamp ring; pipe extended to 2 inches flood elevation.

F. Downspout Nozzles: Bronze round with straight offset bottom section.

G. Area Drains: ASME A112.6.3 with round nickel-bronze strainer and accessories: Membrane flange and membrane clamp with integral grave stop, with adjustable under deck clamp and roof sump receiver (where indicated in the Contract Documents), waterproofing flange.

   a. Area Drain (Outdoor): Cast iron body, with cast iron bar grate, sediment bucket, and flashing collar. Provide Caltrans grate No. D77B when applicable for bicycle traffic.

   b. Area Drain (Indoor): Cast iron body, with buff polished nickel alloy heel proof grate, sediment bucket, and flashing collar.

H. Track and Trench Drain: Cast iron body, heavy-duty, bottom outlet, weep holes, inside calk, anti-tilting grate, with adjustable extending frame and round strainer, as indicated in the Contract Documents, attached to a brass threaded collar for adjustment to varying floor thickness. Provide cast iron, extra heavy traffic pattern gutter or trench drains, where indicated in the Contract Documents.

   1. Refer to Section 05 50 00, Metal Fabrications, for trench drain requirements.

I. Implement hydrocarbon and polychlorinated biphenyls (PCB) absorbing drain inserts when applicable for inlets near fueling and maintenance areas.

2.04 CLEANOUTS

A. Cleanouts shall be provided on all floors and throughout each facility. Cleanouts shall be of the sizes as indicated in the Contract Documents, and shall be of cast iron conforming to ASTM A48/A48M, Class 25B. Cleanout maximum distance shall comply with CPC.

B. Floor cleanouts for parking structures shall be cast iron construction with bronze plug, vandal proof screws and with scoriated cover and membrane clamping device. For all other facilities the top, frame and cover shall be nickel alloy.

C. Wall cleanouts shall be bolted, wedge type having a cover. Cover plate shall be mounted in a flanged frame, shall be stainless steel, and shall be secured to the plug with a vandal-proof screw.

D. Exposed cleanouts shall have a raised brass head cleanout plug.

E. Grade cleanouts shall have an adjustable sleeve housing, with a threaded brass plug, and a countersunk slot.

F. Two-way cleanouts shall be provided at locations where track drainage drains underground.

2.05 MANHOLE COVERS AND FRAMES:

Refer to Section 33 05 16, Utility Structures, for requirements.

2.06 ESCUTCHEONS:

Provide escutcheons in accordance with Section 20 20 13, Pipe Sleeves, Supports, and Anchors for Facility Services.

2.07 VALVES

A. Provide valves of types as indicated in the Contract Documents.

B. Refer to Section 20 10 13, Common Materials and Methods for Facility Services – Fire Suppression, Plumbing and HVAC, for gate valves and swing check valves.

2.08 STORM DRAIN MARKERS

A. Provide a storm drain marker for each street or parking lot storm drain inlet with the following features:

1. Material: 304 annealed stainless steel
2. Thickness: 0.062 inches
3. Weight: 0.218 pounds
4. Size: 4 inch diameter
5. Symbol: Fish with wave
6. Text: No Dumping Drains to Bay
7. Color: Blue inner and outer circle
8. Hole: square 0.25 inch by 0.25 inch hole at center of marker
9. Mounting: Per manufacturer’s specifications including theft proof rivet subsurface mount.

PART 3 – EXECUTION

3.01 PREPARATION

A. Excavations shall be free from water and extraneous material immediately before drainage products are installed or placed therein. Bottoms of trenches shall have a six inches of bedding material as specified by the Contract Documents to support the bottom quadrant of the pipe and fittings. Should rock, buried manmade objects, or equivalent, be encountered or should bedding material be unsuitable to support

the products at the elevation indicated in the Contract Documents, excavation shall be continued to an elevation at least eight inches below the elevation and shall be backfilled with clean material to the elevation indicated in the Contract Documents.

B. Interior of pipe, pipe fittings, valves, drains, and cleanouts shall be cleaned before installation.

C. Install sleeves through walls, floors, roofs, and other structures before drainage lines are installed. Piping shall not be installed under walls, foundations, or footings. Invert of sleeves shall be minimum of six inches above the bottom of footings and foundations.

D. Excavations over 4 feet in depth shall be performed in the presence of an OSHA designated Certified Trenching and Excavation Competent person at all times.

3.02 INSTALLATION

A. Excavating and backfilling, including bedding and compacting requirements, shall conform with Section 33 05 28, Trenching and Backfilling for Utilities.

B. Install products as indicated in the Contract Documents. Remove and re-install products disturbed after installation at no cost to the District. Ends of products to which future connections will be made shall be either valved, plugged, or capped, and anchored when left unattended or completed. Connections to existing facilities shall be made with fittings and short bends to suit the actual conditions. Connect products in accordance with the product manufacturer's installation instructions and recommendations.

C. Pipe and fittings shall be set to line and grade before joints are made up. Angular deflections of joints shall not exceed the recommendations of the pipe and fitting manufacturer. Should the alignment require deflection of joints to be in excess of those recommended, use special bends to achieve the deflection indicated in the Contract Documents. Pipe ends and joints shall be prepared in accordance with the manufacturer's recommendations. As a minimum, pipe ends shall be sanded and cleaned, fittings shall be cleaned, and solvent shall be applied to both pipe and fittings in accordance with manufacturer's specifications.

D. Slope horizontal drainage pipes as a minimum two percent downward in direction of flow for all pipes. Support all above grade piping in accordance with Section 20 20 13, Pipe Sleeves, Supports, and Anchors for Facility Services.

E. Make changes in pipe size with eccentric or concentric reducing fittings as applicable. Changes in direction shall be with either 45 degree wyes, long-sweep 1/4, 1/6, 1/8 or 1/16 bends, or elbows. Short sweep bends shall not be allowed unless required due to space limitations and approved by the Engineer.

F. Joints in no-hub cast-iron pipe and fittings shall use double-seal, compression-type molded neoprene gaskets with 316 grade stainless steel or equal tightening bands that shall provide a positive seal.

G. Tighten band and screw assemblies, used in conjunction with hubless type cast-iron pipe, to 60 inch-pounds torque on each band screw with a torque wrench specifically designed for the purpose. Re-torque each screw after not less than 24 hours.

H. Provide escutcheons at finished surfaces where exposed piping, bare or insulated, passes through floors, walls, and ceilings. Fasten escutcheons to floors, walls, and ceilings in accordance with manufacturer's instructions.

I. Install wall sleeves and seals in accordance with Section 20 20 13, Pipe Sleeves, Supports, and Anchors for Facility Services. Sealing members shall be installed so as to provide electrical isolation between the metallic carrier pipe and all metallic components of the sleeve and seal.

J. Provide electrical isolation with no metal-to-metal contact between metallic discharge lines and reinforcing steel at penetrations of reinforced concrete structures.

K. Drains:

1. Area drain rim elevation shall be located such that uniform slope of 1-1/2 percent is maintained from the furthest distance at the perimeter of slab to rim. There shall be no local depression.

2. Maintain integrity of waterproof membranes where penetrated by installing flashing collar or flange so that no leakage occurs between drain and adjoining materials.

3. Roof drainage shall be separately run from track drains and shall not share a common outlet to the main storm drain.

L. Implement di-electric union fittings when applicable, such as when connecting copper and steel piping systems together.

3.03 PIPE CLEANOUTS

A. Cleanouts shall be the same size as the pipe up to and including six inch pipe. Cleanouts for drainage pipe shall consist of a two-way long sweep 1/4 bend or one or two 1/8 bends extended to the location indicated in the Contract Documents. Wall or accessible piping cleanouts shall be tri-Y-pattern, 90-degree branch drainage fittings having screw plugs.

3.04 IDENTIFICATION

A. Identification of storm drainage components shall be as specified in Section 20 40 13, Identification for Facility Services.

3.05 FIELD QUALITY CONTROL

A. Do not cover products to be buried and do not paint products or line segments to be painted until inspecting, testing, and acceptance of those products have occurred.

B. Test installed drainage lines and equipment, with the Engineer in attendance, as follows:

1. Fill drainage lines with water and allow to stand for not less than 30 minutes without leaking; low and intermediate branches shall have been temporarily sealed. Provide test tees having cast iron screwed plugs in the vertical stacks if the drainage lines are to be tested in sections. Accomplish testing of interior lines before lines are concealed. Repair leaks and retest systems until the system exhibits no leaks. Head of water shall not be less than 10 feet.

2. Disconnect force mains from equipment, seal open ends, and fill mains with water, and hydrostatically test to a pressure of 50 psi greater than the normal pumping pressure. Maintain test pressure until the force main system has been examined for leaks. Repair leaks and retest system until no leaks are exhibited. Use testing instruments calibrated by a qualified laboratory in accordance with Section 01 45 00, Quality Control.

3. Test equipment by operation and adjustment of controls. Faulty equipment or controls shall be either repaired or replaced at no cost to the District.

4. Drainage lines shall be inspected via video camera and videos shall be submitted to the Engineer prior to Acceptance.

3.06 CLEANING

A. Cleaning of installed products shall consist of removing foreign material from the surfaces of products and wiping such products clean. Manufacturer’s labels shall remain intact.

3.07 PAINTING

A. Except where indicated in the Contract Document, piping systems shall not be painted. Where pipes are indicated in the Contract Documents to be painted, as exposed pipe in finished rooms, prepare and paint pipe in accordance with Section 09 91 00, Painting.

END OF SECTION 22 14 01

SECTION 22 14 29

SUMP PUMPS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Sump pumps.

B. Motor (for submersible pump).

C. Controls.

D. Guide rails and lifting cables.

E. Portable hoist.

F. Oil absorbents.

G. Discharge piping.

1.02 RELATED SECTIONS

A. Section 20 10 13, Common Materials and Methods for Facility Services

B. Section 20 60 13, Motors for Facility Services

1.03 MEASUREMENT AND PAYMENT

A. General: Separate measurement or payment will not be made for the work required under this Section. All costs in connection with the Work specified herein will be considered to be included or incidental to the Work of this Contract.

1.04 REFERENCES

A. California Plumbing Code (CPC)

B. National Electrical Code (NEC)

C. National Electrical Manufacturers Association (NEMA)

D. National Fire Protection Association (NFPA):

1. NFPA 70, National Electrical Code

1.05 SUBMITTALS

A. Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Submit manufacturers' product data for the equipment, defining size and arrangement, and for related materials, appurtenances, and installation accessories. Submit Shop Drawings and details, installation instructions, wiring diagrams, assembly and other items required for a coordinated installation.

C. Submit certified copies of factory test reports, including manufacturer's certified performance and efficiency curve data for sump pumps.

D. Submit maintenance and operating data in accordance with Section 01 78 23, Operation and Maintenance Data. Include detailed parts lists, lists of recommended spare parts, lubrication and maintenance procedures, troubleshooting procedures, and operating instructions.

1.06 QUALITY ASSURANCE

A. Pump manufacturer shall be a company or firm who has been regularly engaged in the manufacture of sump pumps of similar type and size, and has a history of at least five successful similar installations in operation for at least three years, without excessive maintenance or repair.

B. Sump pumps and their installation shall comply with the requirements of the California Plumbing Code, Chapters 7 and 8, as applicable.

C. Pumps shall not overload at any point on the performance curve. Indicated capacity shall be at midpoint of performance curve and at maximum efficiency region of the efficiency curves.

1.07 SITE CONDITIONS

A. Inspect the conditions of the area where products are to be placed or installed before the work of this Section begins. Provide surfaces and structures capable of supporting the products. Electrical products that serve the equipment shall have been installed, tested, and accepted before pump equipment is started and operated.

PART 2 – PRODUCTS

2.01 SUMP PUMPS

A. Pump Type and Design:

1. Provide non-clogging, automatic, electric-motor driven, submersible, column, close coupled, dry pit, chopper, grinder, centrifugal duplex type pump as indicated.

2. Each pump shall have a pumping capacity as indicated, but not less than 50 gallons per minute against the minimum, total dynamic head (TDH), system curve indicated when pumping water at 65 degrees Fahrenheit with a specific gravity of 1.04 and containing less than ten percent solids up to 2 inches in diameter at a maximum speed of 1750 revolutions per minute (RPM). Each pump shall operate between 70 percent and 120 percent of the best efficiency point when operating at the average TDH system curve. Each pump shall have the impeller sized such that the developed pump horsepower is no more than 95 percent of its nameplate horsepower at nameplate voltage and speed conditions anywhere within the normal operation range of the pump.

3. Pumps shall be capable of running dry without damage to the motor or pump.

4. Pumps shall be capable of handling wastewater continuously, 24 hours per day, with regular scheduled maintenance.

5. Provide submersible pumps with a cast iron fixed discharge elbow and removable pump and motor unit with guide rail disconnect system fabricated from Type 316 stainless steel. The guide rail disconnect system in conjunction with portable hoist system with Type 316 stainless steel cable and hardware, shall permit easy removal of each pumping unit for inspection or service without requiring personnel to enter sump. Fixed discharge elbow shall be anchored to pit floor using Type 316 stainless steel epoxy anchors and hardware. Simple expansion anchors are not acceptable.

6. Submersible pumps, when lowered into place, shall be automatically connected to the discharge piping. There shall be no need for personnel to enter the wet well to inspect or service the pumps. Provide a portable hoist system capable of lifting or lowering the pump between the wet well and pump access floor. Pump discharge check valves and isolation valves shall be located in a separate dry well, equipped with a drain pipe with minimum 3 inch diameter draining back to wet well by gravity.

7. Chopper/grinder pumps shall be capable of chopping/grinding wood, rags, plastics, and other miscellaneous materials.

8. Volute casing, motor enclosure and discharge shall be cast iron.

B. Impeller:

1. Impeller shall be a cast-iron non-clog design, in a natural hydraulic balance and capable of passing solids, fibrous material, and heavy sludge. Provide impeller with long-throughway having no acute turns.

2. Impeller shall be fastened and locked to the shaft to preclude material movement and to prevent loosening by reverse rotation.

C. Shaft:

1. Provide Type 316 stainless steel pump shaft or shaft bushing capable of maximum bearing and seal life with minimum deflection.

2. Shaft shall not distort under maximum operating conditions.

D. Bearings:

1. Pump shall be designed so that axial and radial loads are transferred to the motor bearings.

2. Bearings shall be designed for a minimum of 25,000 hours B-10 life of continuous operation under the specified conditions.

3. Provide sealed, antifriction, pre-lubricated bearings with a design lubricant quantity equivalent to not less than 50,000 hours of continuous operation.

E. Seals:

1. Provide pump with easily replaceable tandem mechanical seal. Seal faces shall run in an oil reservoir equipped with a conductivity type moisture intrusion sensor and remote moisture alarm.

2. Equip tandem seals with lower seal consisting of one stationary and one rotating silicone-carbide ring, and upper seal consisting of one stationary silicone-carbide ring and one rotating carbon ring. Each pair shall be in contact by a separate spring.

2.02 MOTOR (FOR SUBMERSIBLE PUMP)

A. Refer to Section 20 60 13, Motors for Facility Services, for general requirements.

B. Enclose motor in an air-filled, watertight casing with Class F, moisture-resistant insulated windings, and NEMA 1 Design, B rated at a temperature not more than 155 degrees Celsius.

C. Provide a motor with cooling characteristics that will permit continuous operation in a totally submerged, partially submerged, and non-submerged condition.

D. Separate cable junction box and motor, by either a stator-lead sealing gland or terminal board, in a manner that will isolate motor from water and solids gaining access through pump top.

E. Provide a stator high temperature detector and remote alarm.

F. Provide motor lead and float switch cables of sufficient size length and sheathing for the required service.

G. For column and dry pit, provide close-coupled open drip-proof, non-overloading electric motor. Provide conduit box attached to motor.

H. The power for the sump pump motors shall be provided by feeding from two separate and distinct utility substations.

I. Sump pump motors shall be equipped with a weatherproof device consisting of a combination twist-lock plug and receptacle. The receptacle shall have a threaded cap with a liquid-tight seal to eliminate access to live parts when the motor plug is not connected. The sump pump motor thermal and seal oil chamber moisture sensors shall be provided with a separate weatherproof twist-locked type plug and receptacle device. These devices shall be NEMA 4X, UL listed and comply with the requirements of NEC on Motors, Motor Circuits and Controllers Disconnecting Means.

2.03 CONTROLS

A. Pump controls shall be duplex alternator, Warrick Controls Inc., Series 67, a District Designated Matching Product (DMP). Pump controls shall be enclosed in a Type 316 stainless steel NEMA 4X enclosure complete with main disconnect/circuit breaker and alternator designed to operate on 480 V, three phase, 60 Hz power supply. Provide for each pump motor, a circuit breaker, starter having three phase overload protection with manual reset, magnetic contactors, and a hand-off-automatic selector switch. Provide control circuit transformer with disconnect and overload protection, and automatic electrical alternator. All disconnect switches shall be accessible from outside the control panel, liquid level controls, and control circuit transformer shall be wired on the main disconnect side of the switch. The main circuit breaker disconnect switch shall be accessible from exterior of panel.

B. Level controls shall be District Designated Matching Product (DMP), Warrick Wire suspended probe Type, part number 3W2, with PVC housing, and Type 316 stainless steel probe.

C. Controls shall permit alternate operation of duplex pumps, and shall be set to activate one pump when the sump water level rises to the first preset pump start level, to activate the second pump while the first pump remains in operation when the sump water level rises to a second preset level, and to continue operation of both pumps and activate an alarm when the sump water level rises to a third preset level. Both pumps shall shut down automatically when the sump water level is down to the duplex pump stop level. The height of the first preset water level shall be at least 6 inches above the pump intake and a 6 inch minimum separation between each pump level.

D. Controls shall permit continuous operation of simplex pumps, and shall be set to activate pump when the sump water level rises to the preset pump level start level. The pump shall shut down automatically when the sump water level is down to the pump stop level (6 inches minimum below the first preset pump start level).

E. Provide Form C dry contacts for local and remote monitoring indicating the following alarms and status indicators: high water level, motor thermal sensor, moisture detection, pump failure, loss of power, 30 minute run time, low voltage, pump running and Hand-Off-Auto (HOA). Ensure all alarms and status indications are sent to supervisory control and data acquisition (SCADA).

F. An alternator for duplex or triplex units shall be provided.

G. Provide motor starters, overload and disconnect function as specified under Division 20, Facility Services, Division 26, Electrical, and Division 33, Utilities.

H. Precalibrate control unit to match motor characteristics and factory seal to ensure trip setting is tamperproof. Wire pump controls to terminal strips for connection to external wiring.

I. For small simplex pumps less than 60 gallons per minute (GPM) provide liquid-level sensors, each consisting of a water proof switch in a smooth, pear-shaped, chemical-resistant, polypropylene casing suspended on its own cable.

J. Provide time delay on motor starting so that, during power failure, when power is restored, both pumps will not start simultaneously and trip out.

K. Provide high water alarm low, voltage alarm, and moisture detector alarm.

L. Pumps shall be equipped with non-resettable hour-cycle meters. Submersible pumps shall be equipped with moisture sensors and alarms.

M. Pumps shall be equipped with a time delay relay set at 30 minutes (unless otherwise directed by the Engineer) that will send a signal to Operations Control Center (OCC) if one of the pumps runs continuously over 30 minutes.

N. The following level arrangements shall be used for the associated pump configurations:

1. Duplex pump stations – a low level all pumps off, followed by a primary pump on, a secondary pump on, and a high level alarm.

2. High volume triplex pump stations – a low level all pumps off, followed by the primary pump on, secondary pump on, and the third pump on with high-level alarm.

2.04 GUIDE RAILS AND LIFTING CABLES

A. Provide Type 316 stainless steel guide rails, pipe and mounting brackets as required, for a complete package ready for installation.

B. Provide pump centerline connected guides to allow ease of up-down movement of pump in guide rails.

C. Provide Type 316 stainless steel, lifting chain with a clevis at each end (hooks shall not be used) for securing to the pump and to eyes at sump cover level. Provide a chain sufficiently long to ensure proper seating of the pump discharge assembly connection, using a safety factor of five applied to the pump/motor assembly, and without interfering with normal pump operation.

D. Unless otherwise indicated, provide a heavy-duty galvanized steel, aluminum or cast-iron construction cover with removable hatch of adequate size to allow unrestricted removal of the pump through the opening.

2.05 PORTABLE HOIST

A. For all pump types, provide a portable hoist system capable of lifting and lowering the pump between the wet well and pump room floor as indicated. Hoist shall be equipped with stainless steel wire cable of at least 1.5 times the depth of the sump. Hoist shall be rated at 125 percent of design load and capable of rotating that load 360 degrees.

B. The portable hoist system shall be a complete assembly that can be easily removed, transported and used at various locations as indicated.

C. Each sump pump shall be provided with a floor-mounted steel holder (socket-type) at the pump room floor to support the portable hoist. The holder shall be painted “yellow”.

2.06 OIL ABSORBENTS

A. Provide two oil absorbents per sump as indicated. The oil absorbents shall be a pillow type, dimensions of 18 inches by 22 inches by 3 inches. Absorbent material shall be shredded polypropylene foam type suitable for holding oil while repelling water.

B. Oil absorbent pillows shall have a grommet attached so they can be tethered. Each absorbent pillow shall be tied to a rope that shall be fastened to a hook near the access hatch. The rope shall be a twisted polypropylene rope, yellow in color, 3/16-inch diameter, and of length sufficient to allow free floating even at lowest water level.

2.07 DISCHARGE PIPING

A. Refer to Section 20 10 13, Common Materials and Methods for Facility Services for general piping requirements.

B. Discharge piping shall be sized such that the discharge velocity does not exceed 10 feet per second.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install, align, connect, and test the equipment in accordance with the pump manufacturer’s installation instructions and recommendations.

B. Place pump unit in a sump as indicated.

C. Provide electrical connections required for proper pump operation.

D. Provide check valve, gate valve, and union in discharge from pumps above level of sump.

E. Make adjustments required to place system in proper operating condition in accordance with the manufacturer's instructions and recommendations.

F. Remove foreign material, dirt, and debris from sump and pump system.

3.02 TRAINING

A. Refer to Section 01 79 00, Demonstration and Training, for training of BART maintenance personnel requirements.

3.03 FIELD TESTS

A. Perform field test for each sump pump installation with the Engineer present to witness the tests. Field tests should include verification from OCC or other local and remote alarm (HMI) panels. Provide all necessary instruments, test setup, test water connections, labor and tools for testing. Test water shall be made available from point(s) designated by the Engineer. Defective workmanship, materials and equipment shall be corrected or replaced in accordance with the manufacturer's recommendations and to the satisfaction of the Engineer at no cost to the District. All corrected work shall be retested to ensure compliance with these Specifications.

B. Prior to testing, submit to the Engineer for approval, test procedure along with manufacturer's recommendations for startup and test.

C. For test purposes, normal sump discharge shall be bypassed and, where possible test water shall be recycled.

D. Field test shall demonstrate work quality, operation, and performance. Each test attribute shall be completed in the order listed below to the satisfaction of the Engineer. Submit a written record indicating that the items listed have been completed.

1. Remove and reset pump into proper operating position using the lifting system.

2. Measure the length and width of sump, and measure any incoming drainage water. Add test water from water source. Start lead pump, automatically, at designated sump level, and allow to pump down to stop level.

3. Start alternate lead pump, automatically, at designated sump level, and allow to pump down to stop level.

4. Start lead pump, automatically, at designated sump level, and allow to pump down to stop level (proving alternative system).

5. Start lag pump, automatically, at designated sump level, and allow to pump down to stop level (proving alternative system).

6. Shut-off pumps. Add water until high water automatic alarm at designated sump level is activated. Check that alarm is received by Central. Turn pumps on simultaneously and allow to pump down to stop level.

7. Add water for pumps (lead and lag) to allow regular operation for a period long enough to test circuit heaters (over loads) and to confirm clean discharge to the downstream sump or to the satisfaction of the Engineer.

8. Run each pump for six minutes and record ampacity and discharge pressure.

9. Perform draw down test on each pump and record the drop in water level over a five-minute period. Calculate the cubic feet of water pumped, add in any incoming water drainage, and convert to GPM.

10. Demonstrate operability of moisture alarm.

3.04 CLEANING

A. Clean exposed sump pump parts and surfaces with clean cloths.

END OF SECTION 22 14 29

SECTION 22 15 00

GENERAL SERVICE COMPRESSED-AIR SYSTEMS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Pipe and pipe fittings.

B. Valve.

C. Utility air compressors.

D. Rotary screw compressors.

E. Air dryer.

F. Compressed air aftercooler.

G. Receivers.

H. Coalescing air filters.

I. Compressor motors.

J. Wiring.

K. Grounding and bonding.

L. Piping accessories.

1.02 RELATED SECTIONS

A. Section 09 91 00, Painting.

B. Section 20 10 13, Common Materials and Method for Facility Services.

C. Section 20 20 13, Pipe Sleeves, Supports, and Anchors for Facility Services.

D. Section 20 40 13, Identification for Facility Services.

E. Section 20 50 13, Raceway for Facility Services.

F. Section 20 60 13, Motors for Facility Services.

G. Section 26 05 24, Low Voltage Wires and Cables.

H. Section 26 05 26, Grounding and Bonding for Electrical Systems.

I. Section 26 24 22, Motor Starters and Contactors.

1.03 MEASUREMENT AND PAYMENT

A. Separate measurement or payment will not be made for the work required under this Section. All costs in connection with the Work specified herein will be considered to be included or incidental to the Work of this Contract.

1.04 REFERENCES

A. American Society of Mechanical Engineers (ASME):

1. ASME B.16.22 Wrought Copper and Bronze Solder Joint Pressure Fittings.
2. ASME B.16.3 Malleable Iron Threaded Fittings.

B. American Society for testing and Materials (ASTM):

1. ASTMA53 Specification for pipe, steel, black and hot-dipped zinc-coated, welded and seamless.
2. ASTMA234/A34M Pipe fitting, flange fittings, and flanges, steel and malleable iron (threaded and butt welding), class 150.

C. Manufacturers Standardization Society of the Valve and Fittings Industry (MSS):

1. MSS SP-80 Bronze Gate, Globe, Angle and Check Value.
2. MSS SP-110 Ball Values threaded, socket welded, solder joint, groove and flared ends.

D. Trade Standards: Compressed Air and Gas Institute (CAGI):

1. CGAG – 7 = Compressed Air for Human Respiration.
2. FSWW-V-54 Valve, Gate, Bronze.
3. FSWW-V-35 Valve Ball.

1.05 SUBMITTALS

A. General: Refer to Contract Specifications Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Product Data:

1. Air-to-Air Pressure Booster (Amplifier).
2. Receiver Tank.
3. Combination Coalescer/Filter.

C. Certificate of Compliance: Submit such certified test reports for materials and equipment as necessary to demonstrate compliance with specification requirements.

D. Operation and Maintenance Data: Submit operation and maintenance data for the equipment provided in accordance with Contract Specifications Section 01 78 23, Operation and Maintenance Data. Include recommended spare parts list.

E. Submit manufacturer's product data for the equipment, defining size and arrangement, and for related materials, appurtenances, and installation accessories. Include manufacturer's certified performance data.

F. Submit shop drawings and details, installation instructions, wiring diagrams, assembly and other items required for a coordinated installation.

G. Submit certified copies of factory test reports.

H. Submit Electrical and Communication equipment and materials.

I. Prior to field-testing submit to the Engineer for approval the test procedure along with manufacturer's recommendations for startup and test. After testing, submit written records of tests.

PART 2 – PRODUCTS

2.01 PIPE AND PIPE FITTINGS

A. Class E, Type K copper pipe in accordance with Section 20 10 13, Article 2.01 I except grooved fitting coupling gaskets as specified in Section 20 10 13, Article 2.01 I.6, shall be nitrile gasket, Victaulic Type T (Orange Stripe), Gustin Bacon, or equal gasket having resistance to compressed air having synthetic oil. Unions for connecting steel pipe to copper tubing and tube shall be Dielectric union type.

B. Provide expansive joints, in accordance with Section 20 10 13, Common Materials and Methods for Facility Services – Fire Suppression, Plumbing and HVAC.

C. Only PTFE tape shall be used on threaded connection. Paste compound shall not be used.

2.02 VALVES

A. Gate, Globe angle, check, butterfly and ball valves. Refer to Contract Specifications Section 20 10 13, Common Materials and Methods for Facility Services – Fire Suppression, Plumbing and HVAC, for requirements.

B. Air Outlets: (To be District furnished).

C. Air Dryer required.

D. Plug Valves: Plug valves shall have brass or bronze body and plug. Sealing O-rings shall be TFE-coated viton. Snap ring shall be molybdenum stainless steel. End connections shall be as shown on the Contract Drawings.

2.03 QUALITY ASSURANCE

A. The Contractor shall ensure that manufacturer of air compressors and associated hardware is a firm that has been regularly engaged in the manufacture of compressors of similar type and size, and has a history of at least five successful similar installations in operation for at least three years.

B. The Contractor shall ensure that the air compressors electrical equipment and materials quality assurance shall be in accordance with the Contract Specifications.

C. All equipment shall be rated in accordance with CAGI standards.

2.04 SITE CONDITIONS

A. Inspect the conditions of the area where products are to be placed or installed before the work of this Section begins. Provide surfaces and structures capable of supporting the products. Electrical products that serve the equipment shall have been installed, tested, and accepted before equipment is started and operated.

2.05 UTILITY AIR COMPRESSORS

A. Single Stage: Provide heavy duty single stage reciprocating air cooled compressor with positive oil pump lubrication system, suction inlet screen, discharge service valves unit with either cast iron cylinders or aluminum cylinders with cast iron cylinder liners, steel valves, ductile iron crankshaft, splash lubrication, and drive pulleys. Mount compressor head, motor and drive belt on receiver-mounted base with vibration isolators. Rotating drive elements shall be covered by a guard plate or screen.

B. Two Stage: Same as single stage with interstage cooler.

C. Units shall be equipped with the following items:

1. Oil fill and drain plugs.
2. Air intake filter/silencer.
3. Automatic pressure switch.
4. Air receiver.
5. After cooler.
6. Air dryer and operating controls.
7. Control panel.

8. Starter and safety controls.

9. Minimum dual drive belts (where drive belts are used).

D. Motors shall be three phase, 460V, 60Hz and suitable for full voltage across the line starting. Motor enclosure shall be totally enclosed fan cooled or non-ventilated. Motors shall be provided and factory tested in accordance with Contract Specifications Section 20 60 13, Motors for Facility Services.

E. Motor starters shall be across the line magnetic starter operable on 480V, three phase, 60Hz supply. Motor starters enclosure shall be NEMA 4 type. Enclosure shall be manufactured to fit single or dual starters with the necessary auxiliary relays, terminal blocks, other associated electrical components. Compressor controls, indication lights, and local annunciator. Motor starters shall be provided and factory tested in accordance with the Contract Specification Section 26 24 22, Motor Starters and Contactors.

2.06 ROTARY SCREW AIR COMPRESSORS

A. Provide rotary screw air compressor with splash type lubrication sized to deliver air at the volume and pressure required for the application, with air cooled after cooler, coalescing type oil filter, air intake filter, silencer and sound attenuation weather resistant housing for outdoor installation.

B. The compressor shall be direct driven by and electric motor having a maximum speed of 1,800 rpm. The motor shall be provided with a magnetic type across-the-line starter, enclosed in a watertight enclosure meeting the requirements of NEMA 4. It shall have a molded case circuit breaker with thermal and overload protection. Guards, meeting OSHA requirements, shall be provided for all exposed moving parts.

C. Safety shutdown devices including, but not necessarily limited to, low oil pressure and high oil temperature devices shall be provided. Safety valves shall be installed on the compressor.

D. The air compressor shall be a self-contained, packaged unit complete with master slave controller, start/stop and high temperature and low oil pressure shut down controls. It shall also be equipped with external connections for electrical, supply and discharge air piping.

2.07 AIR DRYER

A. Air Dryer refrigerant type shall be provided having a rated capacity equal to or greater than compressor capacity and maximum operating pressure. Refrigerated compressed air dryer shall have a built-in oil and dirt removal filter and a pre-cooler section to improve energy efficiency. A separator with moisture accumulator and timer controlled solenoid valve for moisture removal shall be provided to maintain high efficiency separation and prevent moisture carry over. No outside cooling water supply or external cooling packages are allowed.

B. Air Connections: Inlet and outlet connections at same level, factory insulated.

C. Heat Exchangers: Air to air and refrigerant to air coils. Furnish heat exchangers with automatic control system to bypass refrigeration system on low or no load condition.

D. Moisture Separator: Centrifugal type located at discharge of heat exchanger.

E. Refrigeration Unit: Hermetically sealed type to operate continuously to maintain specified 21 degrees Fahrenheit (-6 degrees Celsius) dew point. House unit in steel cabinet with access door and panel for maintenance and inspection.

F. Accessories: Air inlet temperature gage, air inlet pressure gage, on/off switch, high temperature light, power on light, refrigerant gage, air outlet temperature gage, air outlet pressure gage.

2.08 COMPRESSED AIR AFTERCOOLER

A. Construction: Removable tube nests of non-ferrous metal tubes and corrosion resistant tube plates, safety valves, pressure gage, moisture separator, moisture drain valve, water inlet piping with automatic water valve, automatic condensate trap and overflow piping with open funnel.

B. Working Pressure: 135 psi.

C. Discharge: Cool air to within 12 degrees Fahrenheit (seven degrees Celsius) of ambient air temperature at specified flow capacity.

2.09 RECEIVERS

A. Receiver shall be vertical or horizontal as indicated on the Contract Drawings. The receiver shall be an ASME and National Board stamped pressure vessel. A base plate for mounting the compressor shall be welded to the receiver.

B. The following accessories shall be provided:

1. ASME certified pressure relief valve.

2. Gate valve for air discharge.

3. Pressure gage.

4. Manual drain valve.

5. Automatic tank drain.

2.10 COALESCING AIR FILTERS

A. Coalescing air filters shall be provided as specified or indicated. Filters shall be rated to trap all 0.3 micron sized particles and above. Filter shall be rated at minimum 200 psig. A pressure drop indicator shall be provided to show when filter element should be replaced. An automatic moisture drain shall be provided.

2.11 COMPRESSOR MOTORS

A. Motors shall be three phase, 460V, 60Hz and suitable for full voltage across the line starting.

B. Motor enclosure shall be manufacturer standard drop-proof fully guarded type. Motors shall be suitable for mounting as specified in Articles 2.01 and 2.02.

C. Motors shall be provided and factory tested in accordance with Contract Specifications Section 20 60 13, Motors for Facility Services.

2.12 MOTOR STARTERS

A. Motor starters shall be across the line magnetic starter operable on 480V, three phase, 60Hz supply.

B. Motor starters enclosure shall be NEMA 12 indoor type. Enclosure shall be manufactured to fit single or dual starters with the necessary auxiliary relays, terminal blocks, and other associated electrical components. Enclosure door shall be cut out and wired to fit the Contactor provided compressor controls, indication lights, and local annunciator and the DFE air compressor-monitoring unit.

C. Motor starters shall be provided and factory tested in accordance with the Contract Specification Section 26 24 22, Motor Starters and Contactors.

2.13 WIRING

A. Power, control, signal, and communication wiring shall be provided and factory tested in accordance with Contract Specification Section 26 05 24, Low and Medium Voltage Wires and Cables.

B. ACMU and pressure transmitter control and signal wiring shall be shielded twisted pair type.

2.14 GROUNDING AND BONDING

A. Electrical equipment, devices, and materials shall be grounded in accordance with Contract Specifications Section 26 05 26, Grounding and Bonding for Electrical Systems.

2.15 PIPING ACCESSORIES

A. Provide piping accessories of types and sizes as required.

B. Provide escutcheons as specified in Contract Specifications, Section 20 20 13, Pipe Sleeves, Supports, and Anchors for Facility Services.

C. Hose and blowguns.

1. Hose shall be self-retracting nylon air hose. Fittings shall be brass. Each end shall be fitted with a swivel coupling.

2. Blowguns shall have aluminum body. Tamperproof pressure reducers shall limit outlet pressure to 30 psi, and comply with Cal-OSHA requirements.

D. Hose reels: Hose reels shall be enclosed and shall be of heavy steel construction. Drum shall be ratcheting, self-retracting. Hose shall be for intended service.

E. Condensate Trap Drains: Trap drains shall consist of brass, bronze, or 304 stainless steel bowl and internal components. Internal components shall consist of float, outlet valve and piston that automatically open to eject moisture that has collected in the system. Materials shall be compatible with synthetic compressor oils.

F. Wall sleeves and seals shall be in accordance with Contract Specifications, Section 20 20 13, Pipe Sleeves, Supports, and Anchors for Facility Services.

PART 3 – EXECUTION

3.01 INSTALLATION (PIPING)

A. Install piping true to line and grade, supported and guided to ensure alignment under all conditions. Installed piping shall clear obstructions, preserve headroom, and keep openings and passageways clear.

B. All air line branch connections shall be made off the top of the header. All condensate of drain connections shall be made off the bottom. Lines shall be pitched toward drip legs and receivers.

C. Install drip legs and automatic drain traps at all low points in the system. Pipe condensate drains to floor drains or other acceptable locations.

D. Valves shall be accessible for operation and servicing. Valves located in furred spaces shall be accessible through access panels or access doors. Valves shall be installed as required, and shall not be installed having stems located below the horizontal position.

E. Pipe joints on copper piping shall e made with soldered connections unless otherwise noted or required.

F. Threaded joints shall only be made with PTFE sealing tape. Thread sealing compounds shall not be used.

G. Install unions at each connection to valves, equipment, and tanks. Soldered-to-threaded connections shall be made-up with male thread-to-solder adapters.

H. After installation of pipes, end of pipes shall be either capped or plugged. No piping shall be buried, furred in, or concealed before being inspected and tested.

I. Provide access panels in accordance with Contract Specifications, Section 20 10 13, Common Materials and Methods for Facility Services – Fire Suppression, Plumbing and HVAC.

3.02 INSTALLATION (AIR COMPRESSOR)

A. Install, align, connect, and test the equipment in accordance with the manufacturer's installation instructions and recommendations.

B. Install conduits in accordance with Contract Specifications Section 20 50 13, Raceways for Facility Services.

C. Install, connect, and test power cables and control wires in accordance with Contract Specification Section 26 05 24, Low and Medium Voltage Wires and Cables.

D. Install and test motor starters in accordance with Contract Specification Section 26 24 22, Motor Starters and Contactors.

E. Pipe drains to disposal location.

F. Make adjustments required to place system in proper operating condition in accordance with the manufacturer's instructions and recommendations.

G. Set pressure switches as required.

3.03 FIELD TESTS

A. Perform field test for each installation in the presence of the Engineer. The Contractor shall give 48 hours notice to the Engineer prior to the test. Provide all necessary instruments, test setup, connections, labor and tools for testing. Defective workmanship, materials and equipment shall be corrected or replaced in accordance with the manufacturer's recommendations and to the satisfaction of the Engineer at no additional cost to the District. All corrected work shall be retested to ensure compliance with these specifications.

B. Field tests shall demonstrate workmanship, operation, and performance. Each test attribute shall be completed to the satisfaction of the Engineer. Submit written record indicating that the following items have been completed:

1. Compressor starts below switch set point.

2. Compressor stops at switch set point.

3. Automatic drain valve discharges; and

4. Operation of pressure relief valves.

C. Field testing of electrical equipment and devices shall include the field tests specified in the following Contract Specifications Sections

1. Section 20 60 13, Motors for Facility Services;

2. Section 26 05 24, Low and Medium Voltage Wires and Cables

3. Section 26 05 26, Grounding and Bonding for Electrical Systems

4. Section 26 24 22, Motor Starters and Contactors.

D. Test compressed air piping system, pneumatically in sections, to a pressure of at least 150 psi for not less than 15 minutes witnessed by the Engineer. Repair leaks and retest the system until the system is leak free. Use testing instruments calibrated by a qualified laboratory in accordance with Contract Specifications Section 01 43 00, Quality Assurance. Test sequence shall be as follows:

1. Lines will be fully blown out.

2. Lines shall be pneumatically tested.

3.04 ADJUSTING AND CLEANING

A. Make adjustments required to place system in proper operating condition in accordance with manufacturer's instructions and recommendations.

B. Remove foreign materials from the installed air-to-air booster equipment and piping system.

C. Provide training of District personnel in accordance with Contract Specifications Section 01 79 00, Demonstration and Training.

3.05 IDENTIFICATION

A. Comply with the requirements of Contract Specifications, Section 20 40 13, Identification for Facility Services.

3.06 PAINTING

A. Except where indicated, piping systems shall not be painted. Where pipes are indicated to be painted, prepare and paint pipe in accordance with Contract Specifications, Section 09 91 00, Painting.

END OF SECTION 22 15 00

SECTION 22 40 00

PLUMBING FIXTURES

PART 1 – GENERAL

1.01 SECTION INCLUDES:

A. Water closets.

B. Urinal.

C. Lavatory.

D. Lavatory faucet.

E. Service/mop sink.

F. Wash fountain.

G. Shower valve and head.

H. Sink.

I. Garbage disposal.

J. Emergency eyewash.

K. Drinking fountain.

L. Gas fired water heater.

M. Electrical water heater.

N. Floor drain.

O. Floor sink.

P. Planter drains.

Q. Cleanouts.

R. Valves, hose bibbs, and hydrants.

1.02 RELATED SECTIONS

A. Section 05 50 00, Metal Fabrications

1.03 MEASUREMENT AND PAYMENT

A. Separate measurement or payment will not be made for the work required under this Section. All costs in connection with the Work specified herein will be considered to be included or incidental to the Work of this Contract.

1.04 REFERENCES

A. Air-Conditioning and Refrigeration Institute (ARI):

1. ARI 1010 Self-Contained Mechanically Refrigerated Drinking Water Coolers

B. American National Standards Institute (ANSI):

1. ANSI A117.1 Specification for Providing Accessibility and Usability for Handicapped People Using Buildings and Facilities
2. ANSI A112.21.2M Roof Drains
3. ANSI Z358.1 Emergency Eye Wash and Shower Equipment

C. American Society of Mechanical Engineers (ASME):

1. ASME A112.6.1 Supports for Off-the-Floor Plumbing Fixtures for Public Use
2. ASME A112.6.3 Floor and Trench Drains
3. ASME A112.18.1 Finished and Rough Brass Plumbing Fixture Fittings
4. ASME A112.19.1 Enameled Cast Iron Plumbing Fixtures
5. ASME A112.19.2 Vitreous China Plumbing Fixtures and Hydraulic Requirements for Water Closets and Urinals
6. ASME A112.19.3 Stainless Steel Plumbing Fixtures (Designed for Residential Use)

D. Americans with Disabilities Act (ADA):

1. Standards for Accessible Design

E. Federal Specifications (FS):

1. FS WW-P-541/1 Plumbing Fixtures (General Specification)
   FS WW-P-541/2
2. FS WW-P-541/4 Plumbing Fixtures (Lavatories) (Detail Specification)
3. FS WW-P-541/5 Plumbing Fixtures (Sinks, Kitchen, Service, and Laundry
   FS WW-P-541/6 Trays) (Detail Specification)

F. Plumbing and Drainage Institute (PDI):

1. PDI WH-201 Water Hammer Arrestors

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Product Data: Submit manufacturers' product data and illustrations of the specified fixtures and products.

C. Operation and Maintenance Data: Submit maintenance and operating instructions, including spare parts list, for plumbing fixtures in accordance with Section 01 78 23, Operation and Maintenance Data.

D. Test Reports: Submit certified test results and certificates of compliance as necessary to verify conformance with specified requirements.

1.06 SITE CONDITIONS

A. Examine surfaces and structures on, or to, which plumbing fixtures will be installed and anchored before the work of this Section begins. Surfaces that will be concealed by plumbing fixtures shall be finished before fixtures are installed.

B. Provide plumbing rough in and stub-outs to exact locations and conditions of required connections. Electrical facilities providing power to the drinking fountains and water heaters shall be installed, tested, and approved before the drinking fountains and water heaters are installed.

PART 2 – PRODUCTS

2.01 FIXTURES

A. Water Closets: Wall-hung vitreous china closet bowl with elongated rim, having large diaphragm flush valve, siphon-jet flushing action, back outlet, carrier, and white open front seat. Water closet shall conform to ASME A112.19.2, FS WW-P-541/1, Type II, Style D, and shall be equipped with Type IV, Class 4 cover, Type I, Style 1, Model A, Flushometer and Type II carrier.

1. Water closets for physically handicapped and mounting height therefor shall conform to the California Plumbing Code and ANSI A117.1, as applicable.

2. Water closets and associated flushometer valves shall use no more than 1.28 gallons per flush, and shall be a Designated Matching Product as specified in the Contract Documents.

3. Wall-mounted carriers for wall-hung water closets shall conform to ASME A112.6.1, and shall be adjustable cast-iron frame with integral drain hub and vent adjustable spud, including lugs for floor and wall anchorage with threaded fixture studs, nuts, and washers.

B. Urinal: ASME A112.19.2, vitreous china urinal, wall-hung type with large diaphragm flush valve, vacuum breaker, siphon-jet flushing action, integral trap and projecting bowl, and with carrier and fittings designed for wall-hung urinal. Urinals shall conform to FS WW-P-541/2, type I, Style B, Class 3, and shall be equipped with Type I, Style A, Class I Flushometer.

1. Urinals for the physically-handicapped shall conform to the California Plumbing Code and ANSI A117.1, as applicable. Carrier shall be floor-mounted with anchored base feet pipe uprights and hanger plate specifically designed for urinal. Provide mounting height of urinals for physically handicapped that conforms to the California Plumbing Code.

2. Urinals and associated flushometer valves shall use no more than 0.5 gallons of water per flush, and shall be a Designated Matching Product as specified in the Contract Documents.

C. Lavatory: ASME A112.19.2, one-piece ledge back, rectangular bowl with four inch high back, one hole faucet at public facilities and 2 hole faucet, drilled four inches on center, at staff facilities .Lavatory shall be wall-mounted, vitreous china with front overflow, with floor-mounted concealed arm carrier supports, trim, fittings, lever operated, self-closing faucet with 10 second delay in closure and 0.5 gpm flow limiting device. Lavatory shall conform to FS WW-P-541/4, type II with Type IV Faucet, Type III Drain, and Type I Stops and Trap. Hot water shall not be provided for public.

1. Lavatory for the physically handicapped shall conform to the California Plumbing Code and ANSI A117.1, as applicable, with lever-handled mixing faucets. Mounting height shall conform to the California Plumbing Code.

2. Wall-mounted carriers for lavatories shall conform to ASME A112.6.1, and shall be adjustable cast-iron and steel frame with tubular legs, with integral drain hub and vent, including lugs for floor and wall anchorage with threaded fixture studs, nuts, and washers.

3. ASMEA112.19.2 vitreous china self-rimming counter top lavatory, one hole faucet at Public and two hole faucet at Staff with drilling on four inch centers, front overflow, seal of putty, caulking or concealed vinyl gasket.

4. Lavatory faucet and accessories shall be District Designated Matching Product (DMP) as specified in the Contract Documents.

D. Service/Mop Sink: Floor mounted, corner type, 14 gauge, Type 304 stainless steel sink shall be 36 inches by 36 inches, and shall have stainless steel rim guard. The rim shall not be higher than ten inches nor less than eight inches nor narrower than two inches. Drain diameter shall be three inches. Furnish faucet with brace. Faucet shall be District Designated Matching Product as specified in the Contract Documents.

E. Wash Fountain:

1. Bowl: Semi-Circular wash fountain with nine inch deep stainless steel bowl and 54 inch diameter.

2. Accessories: Foot-controlled self-closing valve, spray head with stainless steel support tube and bowl gasket, liquid soap dispenser spray head supply pipe, supporting tube, spud with lock nut and beehive strainer, manual mixing valve, volume control valve, operating mechanism, foot levers and rail, combination stop strainer and check valve.

F. Shower Valve and Showerhead: Valve and head shall be Designated Matching Products as specified in the Contract Documents.

G. Sink:

1. Single compartment bowl: ASME A112.19.3, 22 x 19½ x 6½ inch outside dimensions, minimum 18 gauge thick, Type 304 stainless steel, self-riming and sound deadening coating, with one or three holes for the facet and one 3 1/2 inch diameter recessed drain opening, ledge back drill for trim. Bowl shall be ADA compliant in installation position.

2. Kitchen sink faucet: ASME A112.18.1 and District Designated Matching Product as specified in the Contract Documents, chrome plated with eight inch swivel spout, vandal proof water economy aerator and 4 1/2 inch handle. Tail shall be equipped with fixed chrome plated strainer.

3. Accessories: Chrome plated 17-gauge brass P-Trap and arm with escutcheon, wheel handle stop and rigid supplies.

H. Garbage Disposal: Provide continuous-feed type with hardened stainless steel grinding chamber and elements and 3/4 Hp, permanently lubricated motor with overload protector and manual reset, and listed by nationally recognized testing laboratory. Electrical requirements: 120 VAC hard-wired. Product shall be ADA compliant.

2.02 EQUIPMENT AND APPLIANCES

A. Drinking Fountain: Provide wall-hung drinking fountain accessible to the physically handicapped and conforming to FS WW-P-541/6. Bubbler shall be of vandal-proof design, of polished stainless steel, and shall be operable by a self-closing button or bar. Provide anti-splash design basin of satin stainless steel, with a non-removable drain strainer. Drinking fountain for staff areas shall conform to ARI 1010, and shall operate on 115 V, single phase, 60 Hz power source. Cooling capacity shall be three gallons per hour minimum. Drinking fountain shall be a Designated Matching Product as specified in the Contract Documents.

B. Emergency Eyewash: Provide eyewash that is permanently connected to potable water supply, and complies with ANSI Z358.1, Uniform Plumbing Code and CalOSHA standards. Eyewash station shall include a stainless steel bowl with drain, chrome plated brass stay-open full flow ball valve activated by a stainless steel push handle. Eyewash shall include twin spray heads with individual flow restrictors, flip off dust caps and all required signage. Eyewash shall drain to nearest sewer connection, in a manner that shall not create a tripping hazard or obstruction of path.

C. Gas Fired Water Heater:

1. Type: Automatic, natural gas-fired, vertical storage with integral control.
2. Manufacturers:
   a. A.O. Smith
   b. Bradford White
   c. Or equal.
3. Performance: Storage capacity – (Gal.) & input – (BTU per hour with minimum recovery rate) shall be as indicated in the contract. Maximum working pressure shall be 150 PSI.
4. Tank: Glass-lined with an alkaline borosilicate composition fused-to-steel with single flue passage, flu baffle and draft hood, thermally insulated with one-inch thick (minimum) non-CFC foam and encased in corrosion-resistant steel jacket, baked-on enamel finish, floor shield and legs.
5. Controls: Automatic water thermostat and built-in gas pressure regulator, temperature range adjustable from 120 to 170 degrees Fahrenheit, cast iron or sheet metal burner, safety pilot and thermocouple.
6. Accessories: brass water connection and dip tube, drain valve, magnesium anode, and ASME temperature and pressure relief valve.

D. Electrical Water Heaters

1. Type: Automatic, electric, vertical storage.
2. Performance: Storage capacity – (Gal.) & input – (BTU per hour with minimum recovery rate) shall be as indicated in the contract. Maximum working pressure shall be 150 PSI.
3. Electrical Characteristics:

   For 20 gals or less, provide 277Vac or 208Vac, single phase, powered units with 3,000 or 6,000 watts. For greater than 20 gal, provide 480Vac, 3 phase 60Hz, powered units with 6,000 watts.
4. Tank: Glass lined welded steel, thermally insulated with one-inch thick (minimum) non-CFC foam; encased in corrosion-resistant steel jacket; baked-on enamel finish.
5. Controls: Automatic water thermostat with externally adjustable temperature range from 120 to 170 degrees Fahrenheit, flanged or screw-in nichrome elements, enclosed controls and electrical junction box and operating light. Wire double element units so elements do not operate simultaneously.

6. Accessories: Brass water connections and dip tube, drain valve, magnesium anode, and ASME temperature and pressure relief valve.

E. Floor Drain

1. Floor Drain (FD-1)
    a. ASME A112.6.3; lacquered, cast iron, two-piece body; reversible clamping collar; removable, perforated, sediment bucket; trap primer connection; and round, adjustable, nickel-bronze strainer.
2. Battery Room Floor Drain (FD-2):
    a. ASME A112.6.3; acid resisting, epoxy-coated, cast iron, two-piece body; reversible clamping collar; removable, perforated, sediment bucket; trap primer connection; and round, adjustable, medium duty, stainless steel strainer.
3. Floor Drain (FD-3):
    a. ASME A112.6.3; lacquered, cast iron, two-piece body; reversible clamping collar; removable, perforated, sediment bucket; trap primer connection; and round, adjustable, nickel-bronze strainer with polished bronze funnel.

F. Floor Sink

1. Square, lacquered, cast iron body with integral seepage pan; epoxy-coated, cast iron, dome strainer; sediment bucket; and epoxy-coated, cast iron, half grate.

G. Planter Drains: ANSI A112.21.2; cast iron body with sump.

1. Strainer: Removable cast iron dome with stainless steel screen.
2. Accessories: Membrane flange and membrane clamp with integral gravel stop.

H. Gutter and Trench Drains

1. Provide gutter and trench drains manufactured of heavy cast iron with sediment bucket, integral anchor flange, and flashing clamp where membrane is provided. Provide cast iron, extra heavy, traffic pattern, gutter trench drains, where indicated. Provide cast ductile iron anti-tilt grate unless otherwise indicated.
2. Coordinate with the requirements for trench drains specified in Section 05 50 00, Metal Fabrications.

I. Cleanouts

1. Cleanout to grade (COTG): Line type with lacquered cast iron body and round, scoriated, epoxy-coated, cast iron, gasketed cover.
2. Finished Floor Cleanout (FCO): Lacquered, cast iron body with anchor flange, threaded tip assembly and clamp collar for waterproofing membrane; ABS tapered thread plug; and round, scoriated, nickel bronze, gasketed cover.
3. Interior Finished Wall Cleanout (WCO): Line type with lacquered cast iron body, ABS tapered thread plug, and round stainless steel access cover secured with machine screw.

2.03 VALVES, FAUCETS, AND HYDRANTS

A. Integral Stops: Provide lock-shield, loose-key pattern type with supplies. Exposed fixture fittings and trim shall be either chromium-plated or nickel-plated brass, and shall have polished, bright surfaces.

B. Hose Bibb for Non-Public Areas: Provide brass, with wheel handles, conforming to FS WW-P-541. Inlet shall be 1/2 inch external pipe thread, and spout shall have 3/4 inch hose thread. Hose bibbs shall have vacuum breaker conforming with the California Plumbing Code.

C. Flush Wall Hydrant for Public Areas: Provide encased flush, anti-siphon, complete with integral backflow preventer, nickel bronze casing, bronze interior parts, and non-turning operating rod, with free-floating compression closure valve. Box face and hinged cover shall be polished nickel bronze complete with door lock as shown on standard drawing MS12.

D. Flush Floor Hydrant for Public Areas: Floor Hydrants are to be avoided. When a floor hydrant is the only option provide encased flush, anti-siphon, complete with integral backflow preventer, nickel bronze casing, bronze interior parts, and non-turning operating rod, with free-floating compression closure valve. Box face and hinged cover shall be polished nickel bronze complete with square shoulder lock of same size as operating valve. Provide drain for floor hydrants.

E. Water Hammer Arrestors: PDI WH 201, stainless steel construction, bellows type sized in accordance PDI-WH-201, pre-charged suitable for operation in temperature range from 34 to 250 Fahrenheit and maximum 150 psi work pressure.

2.04 INSTALLATION ACCESSORIES

A. Provide anchoring bolts not smaller than 1/4 inch, of 300-series stainless steel, and with stainless steel or chromium-plated nuts and washers.

B. Connectors for connecting earthenware fixtures to flanges of soil pipe shall be either an elastomeric compound or a neoprene gasket and sealant.

PART 3 – EXECUTION

3.01 EXAMINATION AND PREPARATION

A. Examine products for defects before installation. Remove and replace products found to be defective with new products at no additional cost to the District.

B. Verify locations and adequacy of plumbing and electrical services, rough in, and stub-outs.

C. Provide sleeves, backing and blocking, reinforcement, and embedded anchors in the structure to accommodate fixture and equipment installation. Rough-in dimensions shall conform to the respective product manufacturer's installation instructions and recommendations.

3.02 INSTALLATION

A. Install fixtures, equipment, and appliances as indicated and in accordance with the respective manufacturer's installation instructions and recommendations.

B. Secure fixtures to carriers and equipment with all-thread fasteners, and appliances to supporting surfaces with wedge-type stainless-steel expansion bolts or stainless-steel toggle bolts. Install fixtures having outlet flanges to supporting surfaces. Provide connections between earthenware fixtures and flanges of soil pipe airtight and watertight.

C. Install water supply pipes at right angles to the wall and floor. Connect exposed traps and exposed supply lines to the roughed-in piping system at the wall, unless otherwise indicated.

D. Connect garbage disposal to a separate electrical control switch.

3.03 FIELD QUALITY CONTROL

A. Perform tests of installed products for proper operation in accordance with the respective manufacturer's instructions. Perform tests under the observation of the Engineer.

3.04 ADJUSTING AND CLEANING

A. Adjust installed products in accordance with the respective manufacturer's operating instructions. Leaks and operating noise shall be eliminated.

B. Remove foreign material from the surfaces of the products. Leave manufacturer's labels intact until the work has been accepted, then remove.

END OF SECTION 22 40 00

SECTION 23 05 44

SOUND ATTENUATION FOR HVAC PIPING AND EQUIPMENT

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Sound attenuator.

B. Fill material.

1.02 RELATED SECTIONS

A. Section 01 33 00, Submittal Procedures.

B. Section 01 33 23, Shop Drawings, Product Data, and Samples.

C. Section 01 78 23, Operation and Maintenance Data.

D. Section 09 91 00, Painting.

E. Section 23 31 00, HVAC Ducts and Casings.

1.03 MEASUREMENT AND PAYMENT

A. General: Separate measurement or payment will not be made for the work required under this Section. All costs in connection with the Work specified herein will be considered to be included or incidental to the Work of this Contract.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM E84 Test Method for Surface Burning Characteristics of Building Materials

2. ASTM E90 Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions

3. ASTM E477 Test Method for Measuring Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers

B. National Fire Protection Association (NFPA):

1. NFPA 90A Standard for the Installation of Air Conditioning and Ventilating Systems

C. Sheet Metal and Air Conditioning Contractors National Association Inc. (SMACNA):

1. SMACNA HVAC Duct Construction Standards - Metal and Flexible

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit manufacturer's assembly-type Shop Drawings, indicating dimensions, weight loadings, required clearances, and methods of assembly of component parts.

C. Product Data: Submit manufacturer's product data, including construction sizes, pressure drop and acoustical performance data, for specified sound attenuators. Submit certificates of compliance for products proposed for use.

D. Maintenance Data: Submit maintenance data and parts list for each type of sound attenuator, including "trouble-shooting" maintenance guide. Include this data, product data, and Shop Drawings in maintenance manual in accordance with requirements of Section 01 78 23, Operations and Maintenance Data.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver sound attenuators with identification on outside of casings indicating type of sound attenuator and location to be installed. Avoid crushing or bending, and prevent dirt and debris from entering and settling in sound attenuators.

B. Store sound attenuators so as to protect them from weather and construction work traffic. Where possible, store indoors; when necessary to store outdoors, store above grade and enclose with waterproof wrapping.

PART 2 – PRODUCTS

2.01 SOUND ATTENUATOR

A. Sound attenuators shall be of the factory-fabricated type for low velocity service.

B. Sound attenuators shall be constructed of galvanized steel sheets. Outer casing gage and seam construction shall be equal to or greater than required by SMACNA HVAC Duct Construction Standards - Metal and Flexible for ductwork of the same size and pressure class, but not less than 22 gage. Inner casing shall be perforated plate, 26 gage minimum. Seams shall be lock-formed and mastic-filled.

C. Sound attenuators shall not fail structurally when subjected to an air pressure differential of 10 inches water gage from inside to outside of casing. For attenuators with multiple modules, airtight construction shall be provided by use of duct sealing compound between modules.

D. For a sound attenuator unit rated at 2000 fpm face velocity, the self-noise power levels shall not exceed, and the dynamic insertion loss (DIL) ratings shall not be less than, the values shown in Table 1, as follows:

Table 1 - Sound Attenuator Rating
(dB re 1012 W)

Octave Band	1	2	3	4	5	6	7	8
Mid-Frequency (cycles per second)	63	125	250	500	1000	2000	4000	8000
Self-Noise Power Level	58	52	46	43	42	45	45	39
DIL - 5 feet length	3	8	15	28	30	21	14	10
DIL - 7 feet length	4	12	20	36	38	28	18	12

Values shall be obtained on a test unit not less than 24 inches by 24 inches in size made by a nationally recognized independent certified acoustical laboratory.

E. Airflow capacities shall be as indicated or required. Air pressure drop through the attenuator shall not exceed the value indicated, or shall not be in excess of 15 percent of the total external static pressure of the air handling system, whichever is less.

F. Sound attenuators shall be acoustically rated with metal duct inlet and outlet sections while under the rated airflow conditions measured by independent laboratory in accordance with requirements of ASTM E90 and ASTM E477. Noise reduction data shall include the effects of flanking paths and vibration transmission.

G. Certified test ratings for attenuation, regeneration, and pressure drop shall be furnished. Provide manufacturer's certification that insertion loss ratings, regenerated noise ratings, and pressure drop tests were all made on same identical equipment by an independent acoustical laboratory.

2.02 FILL MATERIAL

A. Provide inorganic, mineral, or glass fiber fill material, of sufficient density to obtain the specified acoustical performance, pre-packed under not less than five percent compression, to eliminate voids due to vibration and pressure variables.

B. Fill material shall be inert, vermin- and moisture-proof, and shall comply with applicable requirements of NFPA 90A.

C. Provide fill material with flame spread index of 25 or less, and smoke developed index of 50 or less, when tested in accordance with ASTM E84 test method.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install sound-attenuation devices and appurtenances as indicated. Conform to SMACNA HVAC Duct Construction Standards - Metal and Flexible and the manufacturer's installation instructions, as applicable.

B. Provide sealed joints to prevent air leakage through cell joints. Streamline leading edges of adjacent cells with continuous nonferrous metal nosing.

C. Provide bracing of internal components of casing to prevent distortion or flutter.

D. Reduction of noise shall be not less than the indicated values.

E. Hangers and devices in exterior locations exposed to the weather shall be painted with corrosion-resistant paint as specified in Section 09 91 00, Painting.

F. Connect ductwork to sound attenuators in accordance with applicable requirements of Section 23 31 00, HVAC Ducts and Casings.

END OF SECTION 23 05 44

SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Testing and balancing of air handling system.

B. Testing of air conditioning units.

C. Testing of heating pumps.

D. Testing of electric duct or unit heating coil.

E. Sound tests.

F. Documentation.

1.02 RELATED SECTIONS

A. Section 01 33 00, Submittal Procedures.

B. Section 01 33 23, Shop Drawings, Product Data, and Samples.

C. Section 01 45 00, Quality Control.

D. Section 23 09 00, Instrumentation and Control for HVAC.

E. Section 23 31 00, HVAC Ducts and Casings.

1.03 MEASUREMENT AND PAYMENT

A. General: Separate measurement of payment will not be made for the work required under this Section. All costs in connection with the Work specified herein will be considered to be included or incidental to the Work of this Contract.

1.04 REFERENCES

A. Associated Air Balance Council (AABC):

1. AABC MN-1 National Standards for Total System Balance.

B. American National Standards Institute (ANSI):

1. ANSI S1.4 Specification for Sound Level Meters.

2. ANSI S1.11 Specification for Octave-Band and Fractional-Octave-Band Analog and Digital Filters.

3. ANSI S1.13 Methods for the Measurement of Sound Pressure Levels.

C. American Society of Heating, Refrigerating, and Air Conditioning Engineers Inc. (ASHRAE):

1. ASHRAE Handbook, HVAC Applications

2. ASHRAE Handbook, HVAC Systems and Equipment

D. National Environmental Balancing Bureau (NEBB):

1. NEBB Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems.

E. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):

1. SMACNA HVAC Systems Testing, Adjusting and Balancing

F. ADC Test Code for Grilles, Registers and Diffusers.

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Warranty: Submit AABC National Warranty Certificate for the completed installation.

C. Preliminary Report: Examine the installed systems and submit a written preliminary report to Engineer indicating any deficiencies in the systems that could preclude the proper adjusting, balancing, and testing of the systems. Resolve deficiencies as required.

D. Agenda: The Contractor shall submit an agenda for approval by the Engineer prior to start of testing and balancing work. The agenda shall include the following information:

1. General description of each HVAC system with its associated equipment and operation cycles for heating, intermediate, and cooling. Where different cycles are used for day and night, they shall be described separately.

2. A complete listing of all airflow and air terminal measurements to be performed.

3. Proposed selection points for sound measurements.

4. Specific test procedures and parameters for determining specified quantities (e.g., flow, drafts, sound levels) from the actual field measurements to establish compliance with contract requirements.

5. Samples of report forms with blank spaces for all data specified herein. These forms shall demonstrate applications of procedures and calculations to typical systems.

E. Test Procedures: Specific test procedures for measuring air quantities at terminals shall be submitted to specify type of instrument to be used, method of instrument application (by sketch), and factors for the following conditions:

1. Air terminal configuration;

2. Flow direction, supply or exhaust;

3. Velocity corrections;

4. Effective area applicable to each size and type of air terminal; and

5. Density corrections unless applicable data are covered elsewhere.

F. Sample Forms: Submit sample forms, if forms other than those prepared by the AABC or NEBB are proposed.

G. Instrument Calibration: Submit certified documentation showing test instrument calibration data and date.

H. Test Reports: Submit certified test reports for each system, including information as specified.

I. Calibration Reports: Submit proof that all required instrumentation has been calibrated to tolerances specified in the referenced standards, within a period of six months prior to starting the project.

1.06 QUALITY ASSURANCE

A. Perform testing, adjusting, and balancing, using the services of an independent testing and balancing agency regularly engaged in the testing and balancing of air and water systems and associated equipment and piping systems. The agency selected shall be a certified member of the Associated Air Balance Council (AABC). The agency shall be independent of the installing personnel or equipment supplier for this project.

B. Work shall be performed in accordance with the agenda specified herein. Procedures and methods specified herein shall be followed and, if not specifically specified herein, shall be performed in accordance with the AABC MN-1; NEBB Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems; SMACNA HVAC Systems Testing, Adjusting and Balancing; ASHRAE Handbook, HVAC Applications; and ASHRAE Handbook, HVAC Systems and Equipment.

C. Provide test results and final reports certified and signed by a professional mechanical engineer currently registered in the State of California.

D. Prior to beginning of the testing, adjusting, and balancing procedures, schedule and conduct a pre-balancing conference with the Engineer, and representatives of installers of the mechanical systems. The objective of the conference is final coordination and verification of system operation and readiness for testing, adjusting, and balancing.

E. Test, adjust, and balance the air systems before testing, adjusting, and balancing of the hydronic, steam, and refrigerant systems, as applicable.

1.07 PROJECT CONDITIONS

A. Pre-Balancing Requirements:

1. Prior to testing or starting, clean inside of each piece of equipment and provide clean filters.

2. Prior to any startup, obtain Engineer's approval of test procedures for airflow testing, adjusting, and balancing.

B. System Operation:

1. Testing and balancing shall not begin until each system has been completed and is in full working order. Put all heating, ventilating, and air-conditioning systems and equipment, including controls, into full operation and continue the operation of the systems during each working day of testing and balancing.

2. Tests shall be performed and adjustments made as necessary to accomplish the design objectives.

3. In systems with two or more operating modes, the system operation in the primary mode shall be tested, balanced, and adjusted. After final adjustment in the primary mode, the secondary modes shall be tested, and the system data recorded. The Engineer will determine whether additional balancing and adjusting are necessary to meet the requirements.

4. In systems with redundant equipment, each piece of equipment shall be tested and adjusted independently to operate within the design criteria.

C. Readjustments: Should corrective measures caused by faulty installation require retesting, adjusting, and balancing, such work shall be performed at no additional cost to the District.

PART 2 – PRODUCTS

2.01 INSTRUMENTATION

A. All systems and related components shall be adjusted to perform as required by the Contract Drawings and Specifications.

B. Operating tests of heating and cooling coils, fans, and other equipment shall be of not less than four hours' duration after stabilized operating conditions have been established. Capacities shall be based on temperature and airflow quantities measured during such tests.

C. Method of application of instrumentation shall be in accordance with the approved agenda.

1. All instruments used for measurements shall be accurate, and calibration histories for each instrument shall be available for examination. Each test instrument shall be calibrated by an approved laboratory or by the manufacturer. The Engineer has the right to request instrument recalibration, or the use of other instruments and test methodology, where accuracy of readings is questionable. Refer also to Section 01 45 00, Quality Control, for requirements.

2. All instruments shall be applied in accordance with manufacturer's certified instructions.

3. Furnish all labor, instruments, and appliances required to perform the specified instrumentation. Permanently installed instruments used for the tests, such as gages and thermometers, shall not be installed until just prior to the tests to avoid damage and changes in calibration.

4. Accuracy of all thermometers shall be plus or minus one graduation at the temperatures to be measured. Graduations shall conform to the following schedule:

Design Temperature Differential Degrees F	Maximum Graduation Degrees F
10 or less	0.5
over 10	1

D. Instruments that require calibration shall have unexpired calibration dates. Instruments shall be calibrated against certified equipment having a known valid relationship to nationally recognized standards. If no national standard exists, the basis for calibration shall be documented and submitted in the final report.

E. Certified documentation of all instrument calibrations shall be submitted in the final report.

PART 3 – EXECUTION

3.01 APPLICABLE STANDARDS

A. Perform testing and balancing in accordance with AABC MN-1 and the hereinbefore-referenced NEBB, ASHRAE, and SMACNA Standards and recommended practices, as applicable.

3.02 PROCEDURES

A. Air Systems: Perform the following minimum tests and balancing:

1. Adjust all air handling systems to provide the required design air quantity to, or through, each component. Adjusting and balancing of all systems shall be conducted during periods of the year approximating maximum seasonal operations, to the extent possible.

2. Equalizing devices shall be adjusted to provide uniform velocity across the inlet duct side for supply of terminals prior to measuring flow rates.

3. Flow adjusting, volume control devices shall be used to balance air quantities only, proportioning flow between various terminals comprising system and only to the extent that their adjustments do not create objectionable air motion or sound in excess of specified limits.

4. Balancing between runs, sub mains, branch mains, and branches shall be accomplished by flow regulating devices at, or in, the divided-flow fitting.

5. Restriction imposed by flow regulating devices in or at terminals shall be minimal. Final measurements of air quantity shall be made after the air terminal has been adjusted to provide the optimum air patterns of diffusions.

6. Total air system quantities shall be varied by adjustment of fan speeds or axial-flow fan wheel blade pitch. Damper restriction of a system's total flow may be used only for systems with direct-connected fans without adjustable pitch blades, provided system pressure is less than 1/2 inch w.g. and sound level criteria are met.

7. Where air-measuring systems specified in Section 23 09 00, Instrumentation and Control for HVAC, are provided, such systems shall be used to measure applicable total system branch duct and terminal airflows herein required.

8. Except as specifically indicated herein, Pitot tube traverses shall be made of each duct to measure airflow therein. Pitot tubes, associated instruments, traverses, and techniques shall conform to the ASHRAE Handbook, HVAC Applications; and ASHRAE Handbook, HVAC Systems and Equipment.

9. Pitot tube traverses may be omitted, provided the duct serves only a single room or space and its design volume is less than 2000 cfm. In lieu of Pitot tube

traverses, airflow in the duct shall be determined by totaling volume of individual terminals served, measured as specified herein.

10. Where duct design velocity and air quantity are both less than 1000 fpm/cfm, air quantity may be determined by measurements at terminals served.

11. Test holes, specified in Section 23 31 00, HVAC Ducts and Casings, shall be in a straight duct, as far as possible downstream from elbows, bends, take-offs, and other turbulence-generating devices, to optimize reliability of flow measurements.

12. Measurement of flow rates by means of velocity meters applied to individual terminals, with or without cones or other adapters, shall be used for balancing. Each air terminal shall be tested and adjusted to within 10 percent of design air quantity at final balance. Measurement of air quantities at each type of air terminal (inlet and outlet) shall be determined by the method approved for the balancing agenda. Laboratory tests shall be conducted to prove accuracy of methodology when so directed.

13. Air motion and distribution shall be as indicated. In addition to air motion measurements, perform one smoke test for each supply air system at a location selected by the Engineer at time of tests to demonstrate the air distribution from air terminals.

14. Adjustment of automatically operated dampers shall be set to operate as indicated. Controls shall be checked for proper calibration. A list of controls requiring adjustment shall be submitted to the Engineer for review.

B. Air Conditioning Units: Test air-conditioning unit, including the air-cooled condensing unit and the evaporator coils, as one entity. Check and adjust the system for proper operation under available system cooling load. Test and check the following equipment and operation:

1. Airflow across evaporator coil, cfm;

2. Evaporator coil face area, square feet;

3. Evaporator coil velocity, fpm;

4. Evaporator coil entering air, dry-bulb and wet-bulb temperatures;

5. Evaporator coil leaving air, dry-bulb and wet-bulb temperatures;

6. Evaporator temperature at coil suction connection;

7. Amperage to the compressor motor (rated and actual) when operating;

8. Condenser entering ambient air temperature, dry-bulb;

9. Fan speed (rpm) and, amperage (rated and actual) of each condenser fan and evaporator fan;

10. Condenser airflow and temperature rise, all condenser fans operating;

11. Charged refrigeration system pressure at charging connection; and

12. Outdoor air temperature, dry-bulb and wet-bulb.

C. Heat Pumps: Test heat pump, including indoor and outdoor units, as one entity. Check and adjust the system for proper operation under available system cooling and heating loads, in heating and cooling modes. Test and check the following equipment and operations:

1. Airflow across indoor unit coil, cfm;

2. Coil face area, square feet;

3. Coil velocity, fpm;

4. Coil entering air, dry-bulb and wet-bulb temperatures;

5. Coil leaving air, dry-bulb and wet-bulb temperatures;

6. Amperage to the compressor motor (rated and actual) when operating.

7. Outdoor unit coil entering ambient air temperature, dry-bulb;

8. Fan speed (rpm) and, amperage (rated and actual) of each fan, indoor and outdoor unit;

9. Outdoor unit airflow and temperature rise and drop, all fans operating;

10. Charged refrigeration system pressure at charging connection; and

11. Outdoor air temperature, dry-bulb and wet-bulb.

D. Electric Duct or Unit Mounted Heating Coil: Perform the following tests of electric heaters under available system heating loads:

1. Airflow across the coil, cfm;

2. Coil face area, square feet;

3. Coil velocity, fpm;

4. Coil entering air temperatures;

5. Coil leaving air temperatures; and

6. Amperage to the coil (rated and actual) when operating.

E. Sound Levels: Perform the following sound tests in accordance with ANSI S1.13, to demonstrate that compliance with sound requirements is satisfied at each selection point included in the reports, as follows:

1. Sound level measurements shall be taken at times when the building is unoccupied, or when activity in surrounding areas and background noise levels in areas tested are at a minimum and relatively free from sudden changes in noise levels.

    a. Measurements shall be taken with all equipment secured, except that being tested.

    b. The actual sound levels shall be measured at any point within a room not less than 6 feet from an air terminal (such as fan coil unit, VAV box) or room unit, and not closer than three feet from any floor, wall, or ceiling surface.

2. Sound levels shall be measured with a sound meter complying with ANSI S1.4. The "A" scale shall be used to measure over all sound levels. To determine the specified octave band levels, the above sound level meter, set on "C" scale, shall be supplemented by an Octave Band Analyzer complying with ANSI S1.11.

3.03 DOCUMENTATION

A. Test Data Sheets: Test data sheets shall be provided in accordance with the following requirements:

1. Test data sheet forms shall be subject to approval and shall be provided for recording measurement readings and data. These forms may be reproduced from samples supplied by the independent testing and balancing agent.

2. Where computers are used for calculations and data printout is included, standard forms may be used, provided that all information required by the standard forms is included. These forms and an explanation of the computer program shall be submitted for approval.

3. For components not included in the test data sheet forms, the data shall be recorded concisely and logically for submittal.

4. Sheets shall be completed by the independent testing and balancing agent, dated with test dates, and signed by the technician performing the work. Prior to final submittal, the test data sheets shall be reviewed and approved by the testing and balancing agent's engineer or manager. Test data sheets shall be typed for final submittal.

5. Spaces on the data sheet, that are not applicable, shall be indicated with an N/A. Design data, that is not known or not available, shall be indicated with an N/K.

6. Readings or data, that are applicable, but not provided for on the data sheet, shall be included and shall be explained under the heading "Remarks."

B. Certified Reports: Three copies of the reports specified herein, covering HVAC system performance, air motion (fpm), and sound pressure levels, shall be submitted prior to final tests and inspection.

1. Instrument records, including types, serial numbers, and dates of calibration of all instruments, shall accompany the final submittal data.

2. Reports shall identify conspicuously items not conforming to Contract requirements, or obvious deficiencies in design and operation.

3. Approved system flow diagram shall be submitted with the test data sheets and report. Flow diagrams shall indicate measured flows, pressures, and temperatures.

4. The reports shall be certified by an independent registered professional engineer who is versed in the field of HVAC balancing and who is not affiliated with any firm involved in the installation phases of the project. Certification shall include checking of adherence to agenda, of calculations, of procedures, and evaluation of final summaries.

C. System Data: The certified report shall include for each air handling system the following information:

1. Equipment:

   a. Installation data:

      1) Manufacturer and model;

      2) Size;

      3) Arrangement, discharge, and class;

      4) Motor hp, voltage, phase, cycles, and full load amperes; and

      5) Location and local identification data.

   b. Fan recorded test data:

      1) Airflow (supply, return and/or outside air) cfm;

      2) Total external static pressure recorded only where total system delivery cannot be checked by measuring velocity in main circuit;

      3) rpm;

      4) Motor operating amperes; and

      5) Motor operating bhp.

   c. Air temperature test data:

      1) Leaving air temperature, dry bulb and wet bulb;

      2) Entering air temperature, dry bulb and wet bulb; and

      3) Outdoor air temperature, dry bulb and wet bulb.

2. Duct Systems:

   a. Duct air quantities maximum and minimum; main, sub mains, branches, outdoor (outside) air, total air, and exhaust air:

      1) Duct sizes;

      2) Number of Pitot tube pressure measurements;

3) Sum of velocity measurements (Note: Do not add pressure measurements);

4) Average velocity;

5) Recorded (test) cfm; and

6) Design cfm.

b. Individual air terminals (such as supply diffusers, return/exhaust registers, grills):

1) Terminal identification, supply or exhaust, location and number designation;

2) Type, size, manufacturer, and catalog identification;

3) Applicable factor for application, velocity, area, and designated area;

4) Design and recorded velocities - fpm (state "core," "inlet," as applicable);

5) Design and recorded quantities - cfm; and

6) Deflector vane or diffusion cone settings.

D. Sound Level Data: The certified report shall record the sound levels, taken at each selected location, as follows:

1. Source of sound and location.

2. Diagram or description of relationship of sound source to measuring instrument.

3. "A" scale readings:

a. Equipment being tested turned off (ambient); and

b. Equipment being tested turned on (operating conditions).

4. Reading at each specified octave band frequency:

a. Equipment being tested turned off (ambient); and

b. Equipment being tested turned on (operating conditions).

5. Graph showing relationship between pressure levels specified and recorded readings.

E. Equipment Cards: Install at each piece of equipment a "checkout" card showing significant operating temperatures, pressures, amperes, voltages, and brake horsepower. Checkout cards shall be standard five inches by seven inches index cards enclosed in a clear plastic card folder, securely attached to the equipment or to a wall in the immediate area.

3.04 FINAL TESTS AND ACCEPTANCE

A. Tests shall be performed to demonstrate that capacities and performance of HVAC systems comply with Contract requirements.

1. At the time of final inspection, the Contractor shall recheck, in the presence of the Engineer, random selections of data (air quantities, air motion, and sound levels) recorded in the Certified Report.

2. Points and areas for recheck shall be selected by the Engineer.

3. Measurement and test procedures shall be the same as approved for the work forming the basis of the Certified Report.

4. Selections for recheck (specific plus random), in general, will not exceed 25 percent of the total number tabulated in the report, except that special air systems may require a complete recheck for safety reasons.

B. If random tests elicit a measured flow deviation of 10 percent or more from, or a sound level of two dB or more, greater than, that recorded in the Certified Report listings, at 10 percent or more of the rechecked selections, the report will be automatically rejected. In the event the report is rejected, all systems shall be readjusted and retested, new data recorded, new Certified Reports submitted, and new inspection tests made, all at no additional cost to the District.

C. Subsequent to any correctional construction work, such as acoustic corrections, measurement shall be made to verify that associated airflow quantities, as previously measured, have not been disrupted.

D. Following final approval of Certified Reports by the Engineer, the settings of all valves, splitters, dampers, and other adjustment devices shall be permanently marked by the Contractor so that adjustment can be restored if disturbed at any time. Devices shall not be marked until after final acceptance.

3.05 FIELD SERVICES

A. Instruction of District's Personnel: The Testing and Balancing Agency shall instruct the District's personnel in the proper operation, setting, and adjustment of the equipment.

B. Re-inspection: The Testing and Balancing Agency shall make two return inspection trips to the project, one during a period when actual conditions match heating design conditions and one during a period when actual conditions match air-conditioning design conditions, for the purpose of checking out the entire system (or group of systems). The Testing and Balancing Agency shall make additional adjustments as required during the re-inspection.

END OF SECTION 23 05 93

SECTION 23 09 00

INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Control and interlock wiring.

B. Motorized control dampers.

C. Temperature control.

D. Switches.

E. Relays.

F. Control panel.

G. Seven-day controls.

H. Transformer and wiring.

I. Airflow measuring devices.

1.02 RELATED SECTIONS

A. Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.

B. Section 28 31 00, Fire Detection and Alarm System.

1.03 MEASUREMENT AND PAYMENT

A. General: Separate measurement of payment will not be made for the work required under this Section. All costs in connection with the Work specified herein will be considered to be included or incidental to the Work of this Contract.

1.04 REFERENCES

A. National Fire Protection Association (NFPA):

1. NFPA 90A Standard for the Installation of Air Conditioning and Ventilating Systems

2. NFPA 70 National Electrical Code

B. National Electrical Manufacturers Association (NEMA):

1. NEMA DC-3 Low-Voltage Room Thermostats

C. Underwriters Laboratories Inc. (UL):

1. UL 50 Enclosures for Electrical Equipment

D. California Code of Regulation (CCR) Title 24

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit Shop Drawings for each electric control system, containing the following information:

1. Schematic flow diagram of system showing fans, pumps, coils, dampers, valves, and control devices.

2. Label each control device with setting or adjustable range of control.

3. Wiring diagrams indicating all required electrical wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

4. Logic diagrams showing sequence of events and their relationship.

5. Provide details of faces of control panels, including controls, instruments, and labeling.

6. Include sequence of operation.

C. Product Data: Submit manufacturer's technical product data for each control device furnished, with certificates of compliance, indicating dimensions, capacities, performance characteristics, electrical characteristics, finishes of materials, and including installation instructions and start-up instructions.

D. Samples: Submit sample of each type of furnished thermostat cover, in accordance with requirements of Section 01 33 23, Shop Drawings Product Data, and Samples.

E. Operation and Maintenance Data: Submit manufacturer's operating and maintenance instructions for all items of equipment in accordance with Section 01 78 23, Operation and Maintenance Data.

1.06 QUALITY ASSURANCE

A. Electrical Standards: Provide electrical products that have been tested, listed and labeled by UL and comply with NEMA standards.

B. NEMA Compliance: Comply with NEMA standards pertaining to components and devices for electric and electronic control systems.

C. NFPA Compliance: Comply with NFPA 90A where applicable to controls and control sequences.

D. Manufacturer's Qualifications: Motorized dampers shall be engineered and manufactured by a company regularly engaged in the specialized manufacture of precision control dampers.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Provide factory-shipping cartons for each piece of equipment and control device. Maintain cartons through shipping, storage, and handling as required to prevent equipment damage, and to eliminate dirt and moisture from equipment. Store equipment and materials inside, protected from the weather.

1.08 SITE CONDITIONS

A. Examine surfaces and structures where controls will be installed before the work of this Section begins. Provide surfaces and structures capable of supporting the weight of the products. Do not install controls and instruments, subject to adverse effects from vibration or conductive heat transfer, upon a wall or surface that might contribute to such adverse effects without the provision of an isolating base separating said instrument or control from the mounting surface.

PART 2 – PRODUCTS

2.01 PRODUCT REQUIREMENTS

A. Provide electric and electronic control products in sizes and capacities indicated, consisting of dampers, thermostats, clocks, sensors, controllers, and other components as required for a complete installation.

B. Provide manufacturer's standard control system components, designed and constructed as recommended by the manufacturer for the intended purpose and function.

C. Provide electric and electronic control systems with functional and operational features as indicated and as specified herein.

2.02 CONTROL AND INTERLOCK WIRING

A. Provide control and interlock internal wiring, including that required for thermostats, fans, and dampers, unless indicated otherwise. Install wiring in conduit or raceways in accordance with applicable requirements specified under Division – 26. Circuit voltage shall not exceed 120 V.

B. Wiring shall be not smaller than AWG 14 rated at 600 V. Wiring shall conform with the California Electrical Code, NFPA 70 and to the applicable requirements of Division 26 – Electrical.

2.03 MOTORIZED CONTROL DAMPERS

A. Provide motorized control dampers where indicated. Provide parallel blade type for two position and opposed blade type for modulation, providing proportional airflow with damper movement. For all mixing damper applications, the damper operator shall be provided with linkage to obtain a linear flow characteristic. Motorized dampers shall be engineered and manufactured by a company engaged in the regular manufacturer of precision control dampers.

B. Individual damper sizes shall not exceed 48 inches by 48 inches. Where dampers of greater dimensions are indicated, multiple sections shall be bolted together with reinforcing strips at juncture and neoprene gasket sealer.

C. Damper blades shall be designed so as not to sag, twist, flex, bind, or otherwise contribute to faulty operation or leakage, over the specified limit, when subjected to the system pressure. Blades shall be constructed of formed steel sheet, hot-dip galvanized after fabrication, suitable for air velocities to be encountered in the HVAC systems but not less than 16 gauge. Dampers shall be rated for leakage in the full-closed position, at 50 inch-pound torque applied by the control operator. Dampers shall not leak in excess of 20 cfm per square foot at four inches water gauge static pressure.

D. Damper frames shall be constructed of galvanized steel roll formed into a channel with “U” cross section. Dampers shall be provided with replaceable edge seals, installed along the top, bottom, and sides of the frame and each blade.

E. Linkage bracket and 5/16-inch diameter linkage connecting rods shall be galvanized steel. Trunnion rods shall be brass. Setscrews and mounting bolts shall be galvanized. Bearing shall be oilite or molded synthetic.

F. Damper Operators:

1. Damper operators shall be electric, with mount of sufficient quantity and torque to properly position damper against force of airflow against total damper surface. Damper operator shall provide ample closing and holding force against closed damper to ensure leak proof integrity. Modulating operation and positional operation between preset points shall be as specified under sequence of control and shall be provided with spring return for normally closed or normally open positions, as indicated. Modulating operators shall be hydraulic or oil immersed gear train type. Two position, open/close damper operators shall be of electric motor type and shall be provided where required or indicated, and shall be of sufficient capacity to operate the damper under all conditions.

2. Motor operators may be reversing type for proportional control when operating in conjunction with low-voltage modulating controllers. Operators shall also be capable of automatically operating to preset positions when controlled by snap-acting line voltage controllers. Provide for 120 V, 60 Hz service with integral 24 V transformer and auxiliary end switches as required. Operating stroke shall be adjustable from 90 degrees to 160 degrees. Running and breakaway torque shall be suitable for the application. Rotating parts shall be permanently lubricated.

G. Damper operating speeds shall be selected or adjusted so that the operators will remain in step with the controller without hunting, regardless of load variations. Operators acting in sequence with other operators shall have adjustments of the control sequence as required by the operating characteristics of the system.

2.04 TEMPERATURE CONTROLS

A. Space thermostats shall be fully programmable with a digital display, and shall control within plus or minus one degree F of the temperature setting at the thermostat location as indicated. Low-voltage room thermostats shall conform with NEMA DC-3.

B. Settings of the space thermostat shall be electronically lockable or the space thermostat shall have locking cover and shall respond to a change of not over two degrees Fahrenheit. Locking cover shall be of the key-lock type and shall be constructed so that the heating and cooling settings cannot be adjusted without removal of the locking cover. Transformer and fan relay shall be provided for the proper operation of each thermostatic control system as required. Either separate heating thermostats and separate cooling thermostats or dual element heating-cooling thermostats may be provided. Snap-acting thermostats shall be suitable for 120 V, 60 Hz service. Modulating thermostats shall be suitable for 24 V service. Thermostats shall meet requirements of the CCR, Title 24, California Energy Code.

C. Snap-acting type heating thermostats with three or less steps of control shall be provided for electric-resistance type heaters. Thermostat shall operate in conjunction with contacts provided with heater. Heating thermostat with more than three steps of control for electric resistance-type heaters shall be for rated 24 V service, and shall modulate to position the electric motor of a step controller. The contactors of the electric heater, furnished as a part of the heater, shall make or break according to position of step-controller cam. Thermostats shall be provided with external temperature setting devices, factory set for maximum of 75 degrees Fahrenheit. Heating thermostats shall have an adjustable range of at least 15 degrees Fahrenheit below 75 degrees Fahrenheit.

D. Cooling thermostats shall be designed for one or two steps of refrigeration by snap-action controlling one or two refrigeration compressors as indicated. Thermostat shall make on rise in space temperature. Thermostats shall be provided with external temperature setting devices factory set for minimum of 75 degrees Fahrenheit. Cooling thermostats shall have an adjustable range of at least 10 degrees Fahrenheit above 75 degrees Fahrenheit.

E. Heating-cooling thermostats shall be provided with separate temperature sensing elements for each system. Each element shall operate switches to provide single stage control for heating and cooling. Heating and cooling circuits shall be electrically isolated from each other. Heating side scale range shall be manufacturer’s standard with a factory maximum setting of 75 degrees F and an adjustable range of at least 15 degrees Fahrenheit below 75 degrees Fahrenheit. Heating circuit shall have an adjustable heater for heat anticipation. Cooling side scale range shall be manufacturer’s standard with a factory minimum setting of 75 degrees Fahrenheit and an adjustable range of at least 10 degrees Fahrenheit above 75 degrees Fahrenheit. Cooling circuit shall have fixed cooling anticipation

heater. Thermostat shall contain, or a sub base shall be provided containing, selector switches for Heat-Off-Cool and Fan-Auto-On.

F. Remote thermostats shall be duct-mounted or outdoor type. Set point and throttling range-adjusting mechanism for duct-mounted type shall be contained in a corrosion resistive metal case outside the duct. Outdoor compensating thermostat sensing element shall be provided with a stainless steel protective metal shield or housing, and shall be secured where indicated. Controller mechanism shall be mounted indoors where indicated. Reset ratios of the indoor-outdoor compensating thermostat shall be as indicated.

G. Provide the following special thermostats and fan switches where indicated or required:

1. Line-Voltage On-Off Thermostats: Provide thermostats of bi-metal actuated open contact, or bellows actuated enclosed snap-switch type, or equivalent solid-state type; UL-listed at electrical rating comparable with the application. Provide bimetal thermostats that employ heat anticipation. Equip thermostats that control electric heating loads directly, with off position on dial wired to break ungrounded conductors.

2. Combination Thermostat and Fan Switches: Comply with requirements for line-voltage thermostats. In addition, include as integral part of each thermostat, 2-, 3-, or 4-position push-button or lever operated manual switch for control of fan in each unit with type of control as indicated. Label switches “fan on-off,” “fan high-low-off,” “fan high-med-low-off.” Provide factory-fabricated unit, capable of being mounted on 2-gang switch box or mud ring.

3. Low Voltage On-Off Thermostats: Comply with general requirement indicated for line-voltage thermostats. Provide thermostats of bimetal operated mercury-switch type, with either adjustable or fixed universal anticipation heater.

4. Remote-Bulb Thermostats: Provide remote-bulb thermostats of on off or modulating type, as required by sequence of operation. Provide liquid-filled units designed to compensate for changes in ambient temperature at instrument case. Provide capillary and bulb of copper unless otherwise indicated. Equip bulbs in water lines with separate wells of same material as bulb. Support bulbs installed in air ducts securely, to prevent damage and noise from vibrations. Provide averaging bulbs where indicated or specified in operational sequence, consisting of copper tubing not less than 8 feet in length with either single or multiple-unit elements. Extend tubing to cover full width of duct or unit, and support adequately.

2.05 SWITCHES

A. Instrumentation Switches: Provide instrumentation switches as indicated, including the following for safety and operational interlocks:

1. Air flow switches shall be provided as indicated for monitoring the system, safety, and operational interlocks. Switches shall operate when airflow is established and break with no-flow. Extra monitoring contacts shall be provided.

2. The switch shall be snap-acting, diaphragm-operated with pressure operating range adjustable for differential of 0.02-inch water gauge to 0.08 inch water gauge. Electrical characteristics shall conform to requirements of the individual application. Switch shall have stainless steel sampling tubes and shall be duct mounted.

B. Smoke Detectors and Fire Protection Thermostats:

1. Smoke Detectors: Smoke detectors shall be in accordance with the requirements of Section 28 31 00, Fire Detection and Alarm System.

2. Fire Protection Thermostats: Provide UL-listed fire protection thermostats where indicated. Connect thermostats, that are capable of stopping fans in event of excessive temperatures in fan control circuits. Provide thermostats with fixed or adjustable settings to operate at not less than 75 degrees Fahrenheit above normal maximum temperature at their location in air handling system. Comply with requirements of NFPA 90A. Provide thermostats with the following operating features:

a. Provide automatic reset type thermostats, with control circuit arranged to require manual reset at central control panel. Provide pilot light and reset switch on panel, clearly labeled to indicate operation of fire protection thermostat.

C. Interaction with Fire Alarm System: In addition to the fan safety cutoff, fan controls shall be interconnected with the building or station fire alarm system in a manner as specified in sequences of operation included in this Section.

2.06 RELAYS

A. Provide electric switching relays, UL-listed, where indicated and required. Unless otherwise indicated, relays shall be installed within a control cabinet. Relays shall be of line voltage or low voltage general-purpose type unless otherwise indicated as being required of the heavy-duty type.

B. Relay contacts shall be rated for the required amperes per pole for indicated voltage for inductive as well as resistive amperage. In addition, the contacts shall be horsepower and equivalent resistive power (kilowatt) rated.

C. Relay coil ratings shall be in accordance with operating voltages and shall meet UL requirements for Class B coils. For operating voltage indicated coil ratings shall include voltage dropout, maximum and nominal volt-ampere inrush, maximum and nominal sealed volt-amperes, sealed wattages, and open and sealed admittance.

2.07 CONTROL PANEL

A. Control panel shall contain remote pushbutton stations, protective devices, gauges, switches, and other control devices that are not furnished integral with the controlled equipment mounted inside of control cabinet.

B. Control cabinet shall be formed of 14 gauge steel sheet. Control cabinet shall be provided for house controls, control transformer, relays, controllers, terminal strips, and similar devices where required or indicated. Cabinet shall include bezel, hinged key locking door, high/low voltage barrier, sub panel, mounting strip, rough-in ring, canopy light, tube and wire retainer, back cover plate, mounting devices, and miscellaneous attachments. Cabinet shall be factory finished with baked enamel.

C. Instruments shall be flush mounted or back mounted and shall be completely piped and wired to a properly identified terminal strip. Piping and wiring shall be at the rear of the panel within the cabinet. Provide openings for wire and pipe into cabinet. Gauges, switches, pilot lights, and pushbuttons shall be installed through door facing outside.

D. Each control device in/on the cabinet shall be identified by a stainless steel nameplate, that is attached to or is integral with the cabinet. Lettering shall be cut into the plate to a depth of not less than 1/64 inch, and shall show a contrasting color produced by filling with enamel or lacquer, or by use of a laminated material. Painting of lettering directly on surface of the nameplate or cabinet is not permitted.

E. The control panel shall conform to UL 50, the California Electrical Code and NFPA 70.

2.08 SEVEN-DAY CONTROLS

A. Where required, or specified, a seven-day time switch shall be provided. Time switch shall have seven sets of adjustable trippers to set a different ON-OFF program for each 24-hour day, 10-hour spring-wound carryover with automatic electric rewind upon power restoration, and capability to automatically skip manually selected days. Operation of mechanical timer shall not affect operation of the time switch. Each time switch shall have 2-hour cam and outdoor temperature sensor to control length of warm-up periods.

B. Where required or specified, mechanical timer shall be provided for weekend and night operation of the temperature control system. Timer operation shall not affect operation of time switch or weekend and day-night changeover controls Activation of timer shall bypass the changeover controls and activate the day cooling or heating controls and ventilation for the area served by its thermostat and air-handling unit. Timer shall be adjustable for up to 18 hours of operation. Upon expiration of timer operation, the control system shall return to its normal mode.

C. Where specified, control system shall have following capabilities:

1. Weekend changeover for operation on Saturday and Sunday as specified for night cooling and heating.

2. Day-night changeover for indexing automatically to day or night thermostats by time switch.

2.09 TRANSFORMERS AND WIRING

A. Transformers shall be provided for electric or electronic controls when required. For temperature control system, each transformer shall be connected to an electric circuit, that serves no other equipment.

B. Spare circuits in electric panels shall not be used for controls. Control wiring shall not be connected to lighting circuits.

2.10 AIR-FLOW MEASURING DEVICES

A. Factory fabricated devices for direct measurement of static pressure and velocity pressure of air flow through ducting shall be duct-mounted type provided where indicated. Devices shall be provided with flanges to allow insertion in the duct system and shall be of the configuration and size approximating the duct.

B. The permanently installed device shall operate at the design duct velocity and within the operating ranges recommended by the manufacturer. The maximum static resistance of the device to air flow shall not exceed 0.3 times the velocity head for the duct station and 0.6 times the velocity head for the fan station.

C. The device shall not amplify nor generate sound, and shall be provided with total and static pressure sensors and air straighteners. Sensors shall be provided with pressure transmitting tubing and quick disconnect fittings for remote reading of the air flow in cfm and velocity in fpm. Tubing shall be of sufficient length for connection to a portable or stationary airflow meter at normal working level.

D. Air measuring devices shall be tested for air flow accuracy of plus or minus 5 percent using self-verification of standard production models as determined by calibrated orifice, calibrated nozzles, or other recognized standard procedures. Test shall be carried out in an approved independent testing laboratory.

E. Each airflow-measuring device shall have a stainless steel identification label on the unit and companion plastic tag indicating size, model, series, area, and specified airflow capacity.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install systems and materials in accordance with the equipment manufacturer’s instructions and rough-in drawings and details. Install electrical components and use electrical products complying with applicable requirements of Division 20, Facility Services and Division 26, Electrical.

B. Install components and piping, and make all interconnections as required for a complete and operable installation.

C. Control and interlock wiring shall be installed under applicable requirements of Division 26, Electrical, connecting electric control equipment as well as interlocks as indicated.

D. Location of thermostats and other exposed control sensors shall be checked and verified with plans and room details before installation. Unless otherwise indicated, thermostats shall be 60 inches above finish floor.

E. Alarms shall be interlocked with starter switching to bypass alarm when equipment is manually disconnected.

F. Temperature controls, relays, switches, cabinets, and other components shall be securely anchored or fastened to framing members under the surface upon that they are to be installed.

G. Provide a hydrogen sensor in the battery room to provide an audible alarm signal on site and an alarm signal to the Operation Control Center (OCC). Provide and interlock to be activated by the hydrogen sensor to disconnect the battery charging system. Provide a visual signal outside of the entrance to the battery room indicating “Do Not Enter - Hydrogen Gas”.

3.02 TESTING AND ADJUSTING

A. After completion of the installation, the Contractor shall, with the attendance of manufacturer’s authorized representative, completely adjust all control equipment, place the system in operation, and instruct the District’s operating personnel in the operation of the control system. The following shall be performed before commencing the work of Section 23 05 93, Testing, Adjusting, Balancing for HVAC:

1. Components shall have operating pressure differential checked against range required by operating sequence, and necessary adjustments shall be made.

2. Travel of operators and linkage shall be checked and adjusted as required for automatic dampers and valves.

3. Electrical supply wiring to electric components shall be checked for proper connections and voltage. The current demand shall be measured and checked through the component against the nameplate amperes.

4. Each component shall be tested at its full operating range to ensure the required performance.

5. Automatic dampers shall be checked for binding. Those found to bind even slightly shall be made to operate freely.

3.03 START-UP

A. Check electrical supply voltages.

B. Check operation of components providing temperature and pressure at set points of controls.

3.04 POSTING OF CONTROL DIAGRAM

A. Provide control diagram of each system, as prepared by the manufacturer, mounted on wall of mechanical or fan room. Provide a full-size print, framed and mounted on 1/8-inch hardboard covered with clear acrylic plastic sheet.

3.05 SYSTEM ACCEPTANCE

A. Control manufacturer shall submit a report upon completion of the work stating that the system is complete, has been adjusted, has had all hardware and software functions verified, and is operating in accordance with the manufacturer's instructions and these Specifications. Any deviations from specified settings during system adjustment shall be specifically noted.

B. Demonstration of complete system operation shall be made under the observation of the Engineer.

3.06 TRAINING

A. Instruct District's personnel in the operation and maintenance of the control system in accordance with Section 01 79 00, Demonstration and Training.

3.07 SEQUENCES OF OPERATION

A. Electric Heating Coils, Electric Cabinet Convectors, Electric Baseboard Heaters, and Electric Unit Heaters:

1. Requirements: Except as specified otherwise herein, built-in thermostats shall be provided to control terminal heating units.

2. Unit Heater Control: Provide single-temperature room thermostat to cycle fan motor and electric element to maintain constant space temperature. Provide integral residual heat sensor to continue fan operation until element temperature falls below pre-set point.

3. Electric Duct Heater Control: Provide single-temperature room thermostat to maintain constant space temperature by energizing electric strip heaters in one or more stages as indicated. Provide fail-safe operations by providing power shutoff on control signal failure.

B. Ventilating System Control:

1. HVAC Equipment Room:

   a. Provide single-temperature room thermostat to cycle exhaust fan motor as required to maintain constant space temperature.

   b. Exhaust fan shall start when room thermostat senses air temperature of 85 degrees Fahrenheit and above.

   c. Exhaust fan shall stop when room temperature drops below 80 degrees Fahrenheit.

2. Battery Room for Train Control Room:

   a. Exhaust fan shall operate continuously, and shall stop when Train Control Room supply fan stops.

   b. Exhaust fan shall be de-energized when smoke is detected in the Train Control Room.

3. Toilet Room Exhaust: Exhaust fan shall operate continuously.

C. Heating, Ventilating, and Air Conditioning Control:

1. Train Control/Communication (TCC) Room System:

   a. Supply fan shall operate continuously.

   b. When outside air temperature is 55 degrees Fahrenheit Dry Bulb (DB) and above, return air damper shall be at minimum position and outside air damper shall be at maximum position.

   c. When outside air temperature is below 55 degrees Fahrenheit DB, return air damper shall be at maximum position and outside air damper shall be at minimum position.

   d. When outside air temperature is higher than return air temperature, return air damper shall be at maximum position and outside air damper shall be at minimum position.

   e. When room temperature rises above 90 degrees Fahrenheit in the Train Control/ Communications Room, room temperature sensor shall send signal to indicate high temperature alarm at the Station Agent’s Booth and of the Operations Control Center. (Only for station)

   f. Electric heating shall be activated when room thermostat senses air temperature of 60 degrees Fahrenheit and below.

   g. Electric heating shall be de-activated when room temperature rises above 65 degrees Fahrenheit.

   h. Electric heating shall be activated, regardless of room temperature, when space relative humidity exceeds 55 percent and shall be de-activated when the relative humidity drops below 50 percent.

i. System shall be de-energized when smoke is detected in the Train Control/ Communications Room of a passenger station, in the supply air duct, or smoke or high air temperature in the return air duct. (Only for station)

j. Direct expansion (DX) refrigeration system shall be controlled by room thermostat that cycles the compressors to maintain room thermostat temperature setting.

END OF SECTION 23 09 00

SECTION 23 09 01

FAN CONTROL PANELS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. This Contract Specifications Section provides requirements for the design, fabrication, configuration, factory testing, delivery to the Jobsite, installation and field testing of the fan control panels (FCPs).

1.02 RELATED SECTIONS

A. Section 20 40 13, Identification for Facility Services.

B. Section 20 70 26, Common Materials and Methods for Electrical Systems.

C. Section 20 72 25, Factory and Field Testing.

D. Section 20 70 19, Indoor Cabinets, Racks, Frames and Enclosures.

E. Section 20 80 00, Systems Integration Testing.

F. Section 23 33 14, Dampers for Station and Tunnel Ventilation.

G. Section 23 34 14, Fan Motor Units for Station and Tunnel Ventilation.

H. Section 26 05 13, Medium Voltage Cables.

I. Section 26 05 24, Low Voltage Wires and Cables.

J. Section 26 18 42, Medium Voltage Metal-Clad Switchgear.

K. Section 26 33 01, Battery Systems.

L. Section 27 60 00, Supervisory Control and Data Acquisition System.

1.03 MEASUREMENT AND PAYMENT

A. General: Separate measurement or payment will not be made for the work required under this Section. All costs in connection with the Work specified herein will be considered to be included or incidental to the Work of this Contract.

1.04 REFERENCES

A. Refer to Contract Specification Section 01 42 19, Reference Standards for additional requirements.

B. The FCP assemblies and related devices shall be designed, manufactured and tested in accordance with the following standards, as applicable:

1. BART:
    a. Criteria for Supervisory Control and Data Acquisition (SCADA).
2. American National Standards Institute (ANSI):
    a. C1, Specification of General Requirements of a Quality Program.
    b. C37.1, Definition, Specification and Analysis of Systems Used for Supervisory Control and Data Acquisition, and Automatic Control.
3. Institute of Electrical and Electronic Engineers (IEEE):
    a. 730, Standard for Software Quality Assurance Plans.
4. National Electrical Manufacturers Association (NEMA):
    a. IA 2.3, Programmable Controllers Part 3: Programming Languages (IEC 1131-3).
    b. ICS-1, General Standards for Industrial Control and Systems.
    c. ICS-1.1, Safety Guidelines for the Application, Installation, and Maintenance of Solid State Control.
    d. ICS-2, Industrial Control Devices, Controllers, and Assemblies.
    e. ICS-4, Terminal Blocks for Industrial Control.
    f. ICS-6, Enclosures for Industrial Controls and Systems.
5. National Fire Protection Association (NFPA):
    a. 70 National Electric Code (NEC).
    b. 101 Life Safety Code.
    c. 130 Standard for Fixed Guideway Transit and Passenger Rail Systems.
6. Occupational Safety and Health Administration (OSHA)
7. Underwriters Laboratories, Inc. (UL):
    a. 508, Industrial Control Equipment.

1.05 ABBREVIATIONS

AC	-	Alternating Current
EBP	-	Emergency Backup Panel
FCP	-	Fan Control Panel
ICS	-	Integrated Control System
ICS-V	-	ICS-Ventilation

I/O	-	Input/Output
LED	-	Light Emitting Diode
MPR	-	Multifunction Protection Relay
NO	-	Normally Open
NC	-	Normally Closed
OCC	-	Operations Control Center
PCR	-	Programmable Control Relay
PTC	-	Project Test Center
SCADA	-	Supervisory Control and Data Acquisition
SVF	-	Subway Ventilation Fan
UPS	-	Uninterruptible Power Supply
VCP	-	Ventilation Control Panel

1.06 SUBMITTALS

A. Provide submittals in accordance with Contract Specifications Section 01 33 00, Submittal Procedures, Contract Specifications Section 01 33 23, Shop Drawings, Product Data, and Samples, Contract Specifications Section 01 42 19, Reference Standards, and the requirements herein. In case of conflict, the more stringent requirement will take precedence.

B. Listings of the following, “(23 09 01 - XX)”, within this Contract Specifications Section represent the identifying designation of the submittals required herein.

C. The Contractor shall submit names and qualifications of manufacturer of FCP; qualification statement (23 09 01 -1) shall include, but need not be limited to the following data:

1. Manufacturer's quality assurance programs in accordance with ANSI C1.

2. Complete list of projects on which similar equipment specified for industrial/transit projects in the United States have been installed for furnished. List shall include:

   a. Name of authority or user (Include installations of the Owner, if any).

   b. Contract Number(s).

   c. Original installation date(s).

   d. Current condition of equipment.

e. A list of all known failures including apparent cause(s), corrective work affected, and description of equipment service and operating conditions.

3. List of components to be purchased from other manufacturers. Give name of manufacturer, type and characteristic of each item, and include for each the data requested above.

4. Submit full data sheets, including rating, capacity, manufacturer's type and catalog number for all FCP components, including communications, connectors, termination and patch panels, enclosure and control panel.

5. Submit a list of all inputs and outputs from and to all equipment that interfaces with the FCP. As a minimum this list shall include connections to dampers, fans, motor controllers, power switchgear, SCADA, the ventilation control panel (VCP), operation control center (OCC) etc.

D. The Contractor shall submit design data and Shop Drawings (23 09 01 - 2) including, but not limited to the following:

1. Design data: Submit detailed design drawings as follows:

a. Complete development of fan and damper power and control schematics including the FCPs, front panel layouts, programmable relay ladder logic diagrams, monitoring and control schematics, the multifunction protection relay (MPR) I/O list and wiring diagrams.

b. Wiring interconnection diagrams between fan motors, damper module actuators, fan starters, MPRs, FCPs and the SCADA system interface in cabinet 44F.

c. FCP Construction details.

2. Shop Drawings shall include, but not be limited to, the following:

a. Each FCP showing materials and methods of construction, door arrangement, conduit hub and knockout locations, enclosure type, complete internal wiring diagrams, mounting locations and supports for equipment mounted in the panels and cabinets, terminal strip designations, and wire numbers.

b. Each FCP dimensioned plans, elevations, sections, weight, and full mounting details, including required clearances, removable plates or openings and service space around equipment of all components.

c. Product Data: Submit manufacturer's product data for manufactured items as follows:

1) Manufacturer's model number or item identification;

2) UL listing and rating;

3) Critical dimensions and mounting arrangement; and

4) Complete replacement parts list.

d. Each FCP control panel showing layout of pushbuttons and indications.

e. Terminal-to-terminal and full inter-connection drawings between FCP, MCC and dampers for each FCP.

f. Fiber Optic (where applicable):

1) Submit link loss in dBm for each fiber and associated connectors in both directions.

2) Submit data loss margin for each fiber.

E. The Contractor shall submit the quality assurance, quality control submittals (23 09 01 - 3) in accordance with Contract Specifications Section 01 43 00, Quality Assurance; including, but not limited to, the following:

1. Test programs for factory and site tests shall be submitted with samples of all test report forms before testing takes place. The District Representative reserves the right to attend all tests and shall be notified not less than 4 weeks before the intended test dates.

2. The test report shall identify the name of manufacturer, model numbers, serial numbers, and the last date of calibration of test instrumentation. Documentation shall be furnished to verify that test instruments have been calibrated not more than nine months before the tests.

3. Factory Tests shall be carried out on all FCP's and shall include:

a. Check of control and power wiring, correct connections against the drawings, insulation resistance and freedom from shorts and grounds.

b. Functional checking of circuit operation, including relay circuits and operation of switches, push buttons and indications.

c. Simulate communications to SCADA.

F. The Contractor shall submit seismic calculations (23 09 01 - 4) to show compliance with the requirements of the Contract. Submittals shall be signed and sealed by a Registered Professional Structural Engineer Licensed in the State of California.

G. A minimum of 60 Days prior to the commencement of factory testing, the Contractor shall submit a detailed testing plan for Factory Testing (23 09 01 - 5). Factory test plans and reports shall be in accordance with Contract Specifications Section 20 72 25, Factory and Field Testing and Contract Specifications Section 20 80 00, Systems Integration Testing.

H. 60 Days prior to the field testing, the Contractor shall submit a detailed testing plan for Field Testing (23 09 01 - 6). Field test plans and reports shall be in accordance with Contract Specifications Section 20 72 25, Factory and Field Testing and Contract Specifications Section 20 80 00, Systems Integration Testing.

I. The Contractor shall submit recommended spare parts list and special tools list (23 09 01 - 7) in accordance with the Contract Specifications Section 01 78 44, Spare Parts and Maintenance Manuals.

J. Within 30 Days of successfully completing factory testing, the Contractor shall submit a test report with all of the factory testing results (23 09 01 - 8)

K. Within 30 Days of successfully completing field testing, the Contractor shall submit a test report with the entire field testing results (23 09 01 - 9) including certified reports of electrical continuity, insulation, and ground continuity tests performed on installed products.

L. Within 45 Days of successfully completing field testing, the Contractor shall submit Certifications (23 09 01 - 10): A factory-trained manufacturer's representative(s) shall certify in writing that the equipment has been installed, adjusted and tested in accordance with the manufacturer's recommendations. The Contractor shall provide three (3) copies of the manufacturer's representative's certification.

M. Closeout submittals

1. The Contractor shall furnish an Operations and Maintenance (O&M) Manual covering each piece of equipment. The O&M Manual shall include the names, addresses, and telephone numbers of each Subcontractor furnishing or installing equipment and of the local representatives of the manufacturer of each item of equipment. The O&M Manual shall have a table of contents and be assembled to conform to the table of contents with the tab sheets placed before instructions covering the subject. The instruction sheets shall be legible with large sheets of drawings folded in.

2. The O&M Manual shall provide a clear explanation of the theory, operation, and maintenance of the equipment accompanied by photos and schematic, wiring and mechanical assembly diagrams, as required. The O&M Manual shall be indexed and cross-referenced in an easily understood manner. The O&M Manual shall be loose leaf bound and shall include, but not necessarily be limited to, the following information:

   a. Operating instructions.

   b. Troubleshooting and fault isolation procedures for on-site level repair.

   c. A preventive maintenance schedule for inspection, removal and replacement for each component.

   d. Recommended spare parts list for one year's operation.

   e. Bill of Material.

   f. Equipment manufacturer's' descriptive literature including catalog cuts.

   g. (As Built) Record Drawings.

   h. Acceptance factory test reports.

   i. Data loss margin for each fiber optic link.

N. Prior to Substantial Completion the Contractor shall submit Operations and Maintenance Manuals (CDRL WSXDB - 23 09 01 - 11) in accordance with Contract Specifications Section 01 78 23, Operations and Maintenance Data.

O. Prior to Substantial Completion the Contractor shall submit training materials in accordance with Contract Specifications Section 01 79 00, Demonstration and Training.

P. Prior to Substantial Completion the Contractor shall submit a recommended spare parts list in accordance with Contract Specifications Section 01 78 44, Spare Parts and Maintenance Manuals.

Q. Record Drawings: Submit Record Drawings in accordance with Contract Specifications Section 01 78 39, Contract Record Documents.

R. Prior to Substantial Completion the Contractor shall submit Warranty Certificates (CDRL WSXDB - 23 09 01 - 12).

1.07 QUALITY ASSURANCE AND QUALITY CONTROL

A. Refer to Contract Specifications Section 01 43 00, Quality Assurance, and Contract Specifications Section 01 45 00, Quality Control, for hardware quality assurance requirements and IEEE STD 730 for software quality assurance requirements.

B. Electrical Components, devices, and accessories shall be listed and labeled as defined in NFPA 70 Article 100. All components shall be UL Listed.

C. Conform to applicable requirements of the California Electrical Code and NFPA 130.

D. Components of the same type, size, rating, functional characteristics, and manufacture shall be interchangeable.

E. Controls and auxiliary devices shall be tested and certified in accordance with NEMA ICS 2. Certificate of compliance shall be submitted before assembled equipment is shipped.

F. The manufacturer of the FCP's must have a minimum of five years of successful and proven industrial/transit experience of providing equipment similar to the one being furnished under this Contract.

G. Auxiliary equipment, devices, and components comprising the FCP's shall be proven standard products, or equivalent to the standard products of manufacturers engaged in the production of such equipment, devices, and components for at least the past five years.

H. Field testing shall be performed by persons having five or more years of relevant testing experience.

I. Qualifications:

1. Manufacturer's Qualifications: Contractor shall ensure that the manufacturer submits documents to show continuous and current experience in the design, manufacture, assembly, and testing of electrical and electronic control panels and has met all UL requirements.

2. Certified Fiber Optic Technician qualification shall be submitted and approved before work commences.

J. Quality Control Plan: Contractor shall ensure that the manufacturer submits its quality control plan, showing that functional checking on each panel is checked and verified.

1.08 SYSTEM DESCRIPTION

A. The FCPs shall be used to control, protect and monitor the subway ventilation fans and dampers at the ventilation structures. The tunnel ventilation system is part of the fire life safety system for the operation of BART system.

B. A manual local/remote switch is provided on each FCP. In local mode, fans can only be controlled at the FCP with thermal protection and other protective devices enabled. Local operation from the FCPs is intended for maintenance and test purposes only. In remote mode, fans can be started from the VCP or from the OCC workstations. When the switch is moved to the remote position the system shall be in emergency mode (No protective devices enabled).

C. The FCP shall have provisions for a remote maintenance mode. This mode shall be implemented from the OCC workstations and shall allow the operation of the tunnel ventilation system in a maintenance mode (with thermal and other protective devices operational). This maintenance shall not be the default mode of operation. The default mode shall always be the emergency mode.

D. Control of fans and dampers at the VCP or the OCC workstations is by manual fan supply/exhaust/stop or damper open-close commands. In addition, group commands (i.e., multiple fan/damper commands) can be issued from the OCC workstations. In addition to manual control, control by the integrated computer system (ICS) and ICS-V workstations is via scenarios, where the software determines which fan/dampers should operate based on train location, length of the train and location of the smoke/fire event. Based on these user inputs, individual fan/damper controls are sent to the vent structure SCADA PLC located in cabinet 23F.

E. All fans and damper commands sent to a vent structure PLC are momentary. Momentary commands are transferred to the fan starter control circuit where the command is latched by an interposing relay. A contact of the interposing relay is inserted in the fan starter coil circuit along with other fan start permissives such as “damper open” and “permission to start”. The interposing relay is unlatched when the fan run contact is activated. In emergency mode (the default mode) nothing shall interfere with starting of the emergency ventilation fans.

F. Ventilation control is interlocked such that the ventilation equipment is controlled only from one location at anytime. Ventilation control defaults to the OCC but the VCP can take control at any time from OCC. Once a VCP is in control, the OCC can regain control only after the VCP relinquishes control, or if the VCP does not respond after a timeout. Monitoring functions are provided continuously to all systems and are not affected by the interlocking.

G. The FCP shall provide starting of tunnel ventilation fans per the requirements of the latest revision of the BART Facilities Standard (BFS).

1.09 DELIVERY, STORAGE AND HANDLING

A. Refer to Contract Specification Section 01 60 00, Product Requirements for additional requirements.

B. Suitable crating, blocking, and supports shall be provided so equipment will withstand expected domestic shipping and handling shocks and vibration.

C. Equipment shall be weatherproofed for shipment. Connection openings shall be closed to prevent entrance of foreign material during shipment and storage. Internal packing material shall be clearly identified for removal.

D. Equipment shall be handled and sorted in conformance with manufacturer's instructions. One copy of these instructions shall be included with the equipment at time of shipment. FCP shall be stored indoors in a dry location to prevent moisture damage. FCP shall be stored in a location where it is protected from physical damage as well as vermin.

E. Design shipping groups to be shipped by truck, rail, or ship. Additionally ensure shipping groups will fit through the proposed doorways/openings (reference Contract Drawings) without requiring disassembly and reassembly on site. Bolt indoor groups to skids.

F. Acceptance at Jobsite: Equipment shipping paperwork shall include a copy of the certified successful factory testing of the equipment prior to acceptance of the shipment at the Jobsite.

1.10 CONTRACT/JOBSITE CONDITIONS

A. The FCP shall be designed for operation under the following environmental conditions.

1. Ambient temperature: 10 to 122 degrees Fahrenheit.

2. Relative humidity: five to 95 percent relative humidity.

1.11 WARRANTY

A. Refer to General Conditions and Supplementary Conditions for additional requirements.

B. The Contractor shall ensure that in addition to the Guaranty provisions of General Conditions Article GC4.9, a warranty for the FCP's components is provided and signed by the equipment manufacturer and the Contractor agreeing to correct system deficiencies and replace components that fail in materials or workmanship.

PART 2 – PRODUCTS

2.01 FCP CABINETS

A. Wall-mounted FCP cabinets shall conform to Contract Specifications Section 20 70 19, Indoor Cabinets, Racks, Frames and Enclosures. The type of enclosure for the FCP shall be NEMA 12.

2.02 PROGRAMMABLE CONTROL RELAYS

A. Programmable control relays (PCRs) shall be the Easy800 series as manufactured by Moeller or equal. PCRs shall be equipped with sufficient discrete input/output I/O points plus 10 percent spares to satisfy the connections to the associated fan and damper modules, fan starter, MPR, SCADA system and the control and indicating devices on the FCP front panel. The I/O capacity shall be met by using an I/O expansion unit connected to the PCR and/or a second linked PCR with an expansion unit if required.

B. PCR power supplies shall be rated for 120 VAC and powered by the local uninterruptible power supply (UPS).

C. PCR programming software shall be the latest version of Easy-Soft, or equal.

2.03 FCP COMPONENTS

A. Terminal blocks shall be double-row collar type screw terminals with spring action overlapping top plates rated for 30 amperes, 600 volts with barrier strips between each adjacent row of terminal positions. Terminal blocks shall conform to NEMA ICS-4 and UL 50. Each terminal shall have a white marking strip and plastic cover. Provide 25 percent spare terminals. Mount terminal blocks securely to bracket assembly with stainless steel screws and washers. Terminals shall be grouped and segregated for different operating voltages.

B. Cable and Wiring: Cable and wiring shall comply with Contract Specifications Section 26 05 24, Low Voltage Wires and Cables. In order to meet the requirements of NFPA 130, use type RHW (two hour rated) cable for all field cables running from the equipment to the FCP in ducts/plenum. All cable running at track level shall have a low-smoke outer jacket such as polyolefin.

C. Nameplates to comply with the requirements of Contract Specifications Section 20 40 13, Identification for Facility Services.

D. Indicating Lights, Pushbuttons and Selector Switches:

1. Indicating lights, pushbuttons and selector switches shall be 30mm pilot devices.

2. Indicating lights shall use light emitting diode (LED) lamps. The LED lamps shall be replaceable from the front, rated for 120 VAC and 100,000 hours at full voltage, and shall be clearly visible at an angle of 30 degrees and at a distance of 15 feet in a fully lit environment. Colors shall be red or green as shown.

3. Pushbuttons shall be mushroom type, non-illuminated with momentary operators and NO and NC contacts as required. Mushroom buttons shall be red or green as shown.

4. Selector switches shall be two-position, maintained, lever versions or three-position, spring return, knob versions as shown.

PART 3 – EXECUTION

3.01 FCP CONFIGURATION

A. Configure the PCR data base to accommodate the FCP I/O requirements as shown on the Contract Drawings.

B. Configure the PCR control logic to satisfy the following requirements:

1. When a fan start command is issued, either locally or remotely, the FCP shall issue an open command to the fan damper modules and shall issue a start command to the fan starter. If the FCP is in local or a maintenance mode has been activated and the fan damper modules fail to open an indication shall be issued to OCC and the fan shall be shut down.

2. Fan running status, either supply or exhaust, shall be based on satisfying five parameters: fan contactor closed, fan current exceeds a preset set point, phase rotation is indicated correctly and the fan motion detector senses that the impellor direction of rotation and speed exceeds a preset setpoint.

3. Fan stopped status shall be determined by verifying that both fan contactors are deenergized.

4. If one or more damper modules do not provide a fully open or closed indication, a damper trouble alarm shall be generated.

5. When in emergency mode, and a remote fan start command is received, the FCP shall transmit a contact closure to the fan starter to bypass the fan and damper motor overloads, vibration and temperature sensors protection devices and the damper modules fully closed indication and start the fan.

6. In the local or maintenance operation mode, if the fan locked rotor current occurs for 30 seconds as detected by the fan's multifunction protection relay (MPR), close the fan's damper and shutdown the fan.

C. Equipment shall be installed in accordance with the approved Shop Drawings and the respective equipment manufacturer's installation instructions and recommendations.

3.02 FACTORY TESTS

A. Perform factory tests in accordance with the requirements specified in Contract Specifications Section 20 72 25, Factory and Field Testing. The witnessed factory test shall be performed on one FCP.

B. A discrete input hardware simulator shall be used to simulate all inputs from field equipment and SCADA. Discrete outputs shall be verified by observing the LEDs on the PCR discrete output modules and, where applicable, the status and alarm indicating lights on the FCP front panel.

3.03 INSTALLATION

A. Install the FCPs in accordance with Contract Specifications Section 20 70 19, Indoor Cabinets, Racks, Frames and Enclosures.

B. Following the installation of all related equipment including fans, fan starters, MPRs, SCADA cabinet 44 degrees Fahrenheit, etc., terminate all connections as indicated on the plans and the approved Shop Drawings.

3.04 FIELD TESTING

A. Test all wiring in accordance with Contract Specifications Section 26 05 24, Low Voltage Wires and Cables.

B. Verify the correct termination of all field wiring using Contractor-prepared interconnection diagrams.

C. Perform functional tests of each FCP in local control mode including the starting and stopping of the fan and opening and closing the damper. Simulate abnormal conditions and verify that the information is correctly displayed on the FCP. Verify that the information is correctly displayed on the workstations in the Project Test Center (PTC). Testing shall be coordinated with the functional SCADA system requirements specified in Contract Specifications Section 27 60 00, Supervisory Control and Data Acquisition System.

D. Perform functional tests of each FCP in remote control mode including the manual starting and stopping of the fan and opening and closing the damper from the PTC. Verify that fan and damper motor protection is bypassed in Emergency mode. Verify that all devices are functioning properly.

END OF SECTION 23 09 01

SECTION 23 13 23

ABOVE GROUND FUEL STORAGE TANKS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Above ground main tank design and product requirements.

B. Day tank design and product requirements.

C. Piping materials.

D. Fittings and valves.

E. Fuel pumps.

1.02 RELATED SECTIONS

A. Section 01 33 00, Submittal Procedures

B. Section 01 33 23, Shop Drawings, Product Data, and Samples

C. Section 09 91 00, Painting

D. Section 26 32 13, Engine Generators

1.03 MEASUREMENT AND PAYMENT

A. General: Separate measurement or payment will not be made for the work required under this Section. All costs in connection with the Work specified herein will be considered to be included or incidental to the Work of this Contract.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

B. National Fire Protection Association (NFPA):

1. NFPA 30 Flammable and Combustible Liquids Code
2. NFPA 54 National Fuel Gas Code

C. Underwriters Laboratories Inc. (UL):

1. UL 142 Steel Above-ground Tanks for Flammable and Combustible Liquids
2. UL 2085 Protected Above-ground Tanks for Flammable and Combustible Liquids

D. California Fire Code

1. Article 79 Flammable and Combustible Liquids

E. Environmental Protection Agency

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Submit the following:

1. Shop drawings of tanks, containment basins, level and fuel transfer controls, drains, vents, and connections.

2. Layout and connection diagram showing location of all equipment, vents, grounding requirements, and pipe routing.

3. Tank manufacturer's product data.

4. Certificates of Compliance: Manufacturer shall certify that tank will perform as specified.

5. Test reports.

6. Installation instructions.

7. Tank foundation, mounting and seismic anchoring calculations, and details.

PART 2 – PRODUCTS

2.01 ABOVE GROUND MAIN TANK DESIGN AND PRODUCT REQUIREMENTS

A. Manufacture fuel tank in accordance with UL 2085. Tank shall be capable of storing petroleum products with specific gravity up to 1.1 including fuel oils, specifically No. 2 diesel fuel, at temperatures up to 150 degrees Fahrenheit.

B. Provide useable fuel tank volume of 90 percent. Allow 5 percent for sump volume and 5 percent for expansion. Size tank to store fuel supply for engine generator operating at full capacity 24-hour minimum plus exercising the generator for 30◦minutes monthly. Refueling will be performed at six-month intervals. Provide fuel transfer pump(s) and all controls to supply the engine generator or transfer fuel to the day tank depending on design configuration.

C. Provide fill cap with provisions to be locked closed. Provide required vents (emergency and vapor) with rainproof caps. Provide level controls and alarm to indicate fuel level. Provide rupture containment basin with 150 percent of tank capacity and fuel in basin alarm. Alarms generated by the fuel storage and circulation systems shall be transmitted to OCC as well as a local audible alarm.

D. Provide stop cock and plug at tank drain. Provide isolation valve on tank discharge piping with provisions to be padlocked open.

E. Provide fuel distribution system in accordance with manufacturer's recommendations. Comply with recommended practices of NFPA.

F. The internal steel tank shall pass a 5 psig pressure test for a 24-hour period at the factory.

G. Tank(s) shall be tested in accordance with the Uniform Fire Code, Appendix llF, Proposed Test Requirements for Protected Tanks: Standard 79-7 (including impact and ballistic tests).

H. The internal tank shall have an emergency vent as required by the NFPA and Uniform Fire Code.

I. The secondary containment shall have the capability of physical monitoring. Physical monitoring shall be accomplished using an engineer approved leak detection system. External tank connections shall be equal to or larger than 3/4 inch.

J. The internal steel tank shall be encased in 6 inch of concrete minimum and as required to meet impact and ballistic testing.

K. The concrete shall be 6 inch of light-weight insulation concrete that is capable of preventing the internal tank temperature from rising more than 260 degrees Fahrenheit during a 2000 degrees Fahrenheit fire test for 2 hours.

L. The concrete shall not contain any aggregate or pea gravel.

M. The tank shall have an outer steel tank that protects the internal concrete tank.

N. The concrete shall be monolithic (seamless) and contain no cold joints, or heat transfer points between the internal and external tanks.

O. The outer steel tank shall have a two inch vent as required by UL 2085.

P. The internal and external steel tanks shall have continuous welds on all sides.

Q. The steel tank openings shall be threaded except for the leak detector tubes.

R. The tank shall have a saddle support system that meets UBC Zone 4 seismic requirements.

S. Tanks and appurtenances shall have an exterior factory applied prime and finish coating of epoxy paint in accordance with Section 09 91 00, Painting.

T. Tanks shall have warning signs to indicate COMBUSTIBLE, NO SMOKING, a NFPA Placard H=0, F=2, R=0 and No. 2 diesel. Provide an identical NFPA placard on the entrance gate.

2.02 DAY TANK DESIGN AND PRODUCT REQUIREMENTS

A. Manufacture steel tank in accordance with UL 142. Tank shall be capable of storing petroleum products with specific gravity up to 1.1 including fuel oils, specifically No.◦2 diesel fuel, at temperatures up to 150 degrees Fahrenheit.

B. Provide useable fuel tank volume of 90 percent. Allow five percent for sump volume and five percent for expansion. Size the capacity of the day tank for a minimum of five percent of the main fuel storage tank. Provide fuel transfer pump(s) and all controls for refueling of the day tank from the main fuel storage tank. Provide alarms per 2.01C requirements.

C. Provide level controls and alarm to indicate fuel level. Provide required vents (emergency and vapor) with rainproof caps. Provide rupture containment basin with 150 percent of day tank capacity and fuel in basin alarm. Design system to avoid siphoning from one tank to the other. Provide alarms per 2.01C requirements.

D. Provide stop cock and plug at tank drain. Provide isolation valve on tank discharge piping with provisions to be padlocked open.

E. Provide fuel distribution system in accordance with manufacturer’s recommendations. Comply with recommended practices of the Appendix of NFPA. Underground fuel piping is not allowed.

F. The internal steel tank shall pass a 5 psig pressure test for a 24-hour period at the factory.

G. Tank(s) shall be tested in accordance with the Uniform Fire Code, Appendix llF, Proposed Test Requirements for Protected Tanks: Standard 79-7 (including impact and ballistic tests).

H. The internal tank shall have an emergency vent as required by the NFPA and Uniform Fire Code.

I. The secondary containment shall be steel located outside thermal physical protective material.

J. The secondary containment shall have the capability of physical monitoring. Physical monitoring shall be accomplished using an engineer approved leak detection system. External tank connections shall be equal to or larger than 3/4 inch.

K. The internal and external steel tanks shall have continuous welds on all sides.

L. The steel tank openings shall be threaded except for the leak detector tubes.

M. The tank shall have a support system that meets UBC Zone 4 seismic requirements.

N. Tanks and appurtenances shall have an exterior factory applied prime and finish coating of epoxy paint in accordance with Section 09 91 00, Painting.

O. Tanks shall have warning signs to indicate COMBUSTIBLE, NO SMOKING, a NFPA placard H=0, F=2, R=0 and No. 2 diesel. Provide an identical NFPA placard on the entrance gate.

2.03 PIPING MATERIALS

A. All piping shall be ASTM A53, schedule 40 black steel pipe.

2.04 FITTINGS AND VALVES

A. All fittings shall be ANSI B16.3, Class 150 banded, malleable iron, threaded. Connections between dissimilar pipe materials shall be isolated with insulating flanges, unions, or gaskets as necessary.

B. Fuel shutoff valves at the tank(s) shall be ball valves. Valves shall be brass or bronze bodied, stainless steel shaft, chrome plated or stainless steel ball with Teflon seat. Valves shall be rated at 150 psig WOG.

C. Check valves shall be swing type, 150 psig rated, threaded, brass or bronze bodied, with removable stainless steel hinge pin and screwed cap.

D. Pressure relief valves shall be 150 psig rated, threaded, brass or bronze bodied, and be adjustable from 20 to 100 psig.

E. Anti-siphon valve(s): PVMC Type A, Universal 403, EBW 616-300 or equal.

F. Provision for tank grounding shall be provided.

2.05 FUEL PUMPS

A. Provide 120 VAC, single phase, 60 Hz, TEFC motor driven, positive displacement gear pumps. Pumps shall be suitable for exterior service. Pumps shall be rated at 150 psig, cast iron with bronze bearings, mechanical seals, and built in relief valve.

B. Pumps and appurtenances shall be mounted in type 304 stainless steel enclosures with adequate room to access and maintain the pump(s) and equipment.

2.06 FUEL LEVEL

A. All fuel tanks shall be refueled (and full) by the contractor prior to District acceptance.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install tanks and fuel distribution system as indicated, and in accordance with NFPA 30 and the manufacturer's installation instructions.

B. Pitch both tanks 1/4 inch per foot forward toward drain plug.

C. Locate day tank outlet even with engine fuel pump centerline.

D. Provide earthquake restraints on both fuel tanks.

E. The main fuel storage tank shall be surrounded with a reinforced concrete or concrete masonry unit (CMU) wall meeting the ballistic requirements of the Uniform Fire Code.

F. Mount fuel tank(s) and engine generator on an integral concrete slab designed to support the loads. Provide spill containment with proper drainage and drainage treatment.

3.02 FIELD QUALITY CONTROL

A. Prior to engine generator testing, tanks and piping shall be tested in the presence of the Engineer as follows:

1. Air Test: Tank(s) and associated piping shall be pressurized with air to 5 psig for a minimum of 24 hours. The tank(s), fittings, and pipings shall have no more than a 1 psig drop over a period of 24 hours. Air gage shall be calibrated in 1/4 psig increments. Temperature shall be constant during the air test.

2. Soap Test: With tank(s) and associated piping pressurized at 5 psig, a one to two percent solution of household detergent in water shall be applied to exterior surface of tank with sponge or other acceptable means. Leaks revealed by bubbling of soap film shall be marked and, after tank is depressurized, repaired and retested until there are no leaks.

3. After testing, tank(s) and appurtenances shall be thoroughly cleaned and dried.

END OF SECTION 23 13 23

SECTION 23 23 00

REFRIGERANT PIPING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Refrigerant piping.

B. Joining materials.

C. Valves.

D. Fittings.

E. Strainer.

F. Refrigerant driers.

G. Moisture indicators.

H. Sight glasses.

I. Expansion valves.

J. Hot gas bypass valves.

K. Vibration eliminators.

L. Refrigerant.

1.02 RELATED SECTIONS

A. Section 01 33 00, Submittal Procedures

B. Section 01 33 23, Shop Drawings, Product Data, and Samples

C. Section 01 45 00, Quality Control

D. Section 01 78 23, Operation and Maintenance Data

E. Section 01 79 00, Demonstration and Training

F. Section 20 10 13, Common Materials and Method for Facility Services

1.03 MEASUREMENT AND PAYMENT

A. Separate measurement or payment will not be made for work required under this Section. All Costs in connection with the Work specified herein shall be considered to be included as part of the Contract lump sum price indicated in the bid Schedule of the Bid Form for the related item or items of Work.

1.04 REFERENCES

A. Air-Conditioning and Refrigeration Institute (ARI):

1. ARI 495 Refrigerant Liquid Receivers
2. ARI 710 Liquid-Line Driers
3. ARI 730 Flow-Capacity Rating and Application of Suction-Line Filters and Filter-Driers
4. ARI 750 Thermostatic Refrigerant Expansion Valves
5. ARI 760 Solenoid Valves for Use with Volatile Refrigerants

B. American National Standards Institute (ANSI):

1. ANSI B16.22 Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
2. ANSI B16.26 Cast Copper Alloy Fitting for Flared Copper Tube
3. ANSI B31.5 Refrigeration Piping
4. ANSI B31.9 Building Service Piping

C. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE):

1. ASHRAE 15 Safety Code for Mechanical Refrigeration
2. ASHRAE 34 Number Designation of Refrigerants

D. American Society of Mechanical Engineers (ASME):

1. ASME Boiler and Pressure Vessel Code, Section IX, Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators
2. ASME B31.9 Building Services Piping
3. ASME SEC 8D Boilers and Pressure Vessels Code, Rules for Construction of Pressure Vessels

E. American Society for Testing and Materials (ASTM):

1. ASTM A53 Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
2. ASTM A234 Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures
3. ASTM B88 Seamless Copper Water Tube
4. ASTM B280 Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
5. ASTM F708 Design and Installation of Rigid Pipe Hangers

F. American Welding Society (AWS):

1. AWS A5.8 Specification for Filler Metals for Brazing and Braze Welding
2. AWS D1.1 Structural Welding Code, Steel

G. Manufacturers Standardization Society (MSS):

1. MSS SP58 Pipe Hangers and Supports – Materials, Design and Manufacturer
2. MSS SP69 Pipe Hangers and Supports – Selection and Application
3. MSS SP89 Pipe Hangers and Supports – Fabrication and Installation Practices

H. Underwriters Laboratories Inc (UL):

1. UL 429 Electrically Operated Valves

1.05 REGULATORY REQUIREMENTS

A. Refer to Section 20 10 13, Common Materials and Methods for Facility Services – Fire Suppression, Plumbing and HVAC.

1.06 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit Shop Drawings including plans, elevations, and sections of piping layout, and locations of valves, strainers, and equipment to which piping system connects. Submit assembly, erection, and installation drawings.

C. Product Data: Submit manufacturers' product data for specified materials including each type piping, each type valves, driers, moisture indicators, and strainers.

D. Operation and Maintenance Data: Submit operation and maintenance data for equipment provided, in accordance with Section 01 78 23, Operation and Maintenance Data.

E. Welder's Qualifications: Submit Brazer's Certificate signed by the Contractor certifying that Brazer's comply with requirements of ASME, Boiler and Pressure Vessel Code, Section IX.

F. Test Reports: Submit certified test reports for valves and field test results for installed products.

1.07 SITE CONDITIONS

A. Examine surfaces on, or to, which products will be installed before the work of this Section begins. Provide surfaces capable of supporting the weight of such products, and acceptable for the installation of the products. Perform soldering only when the piping is dry and clean.

PART 2 – PRODUCTS

2.01 MATERIALS, EQUIPMENT, AND ACCESSORIES

A. Refrigerant Piping:

1. Provide seamless copper tubing conforming with ASTM B280 and ANSI B31.5, as applicable, except provide Class J for buried underground insulated piping as specified in Section 20 10 13, Common Materials and Methods for Facility Services – Fire Suppression, Plumbing and HVAC. Class J piping may be used for all insulated piping. Use of factory pre-charged piping is permitted.

2. Tubing shall be factory cleaned, ready for installation, and shall have ends capped to protect cleanliness of pipe interior until installed.

3. Valve strainers, dryers, moisture indicators, sight glasses, and vibration eliminators shall be full line size.

B. Joining Materials: Brazing Filler Metals: AWS A5.8, Classification BAg-1 (Silver).

C. Valves:

1. Design, manufacture, and test valves specifically for the service intended. Comply with applicable ARI requirements. Provide removable internal parts for inspection and replacement without applying heat and breaking pipe connections. Direction of flow shall be legibly and permanently indicated on the valve body.

2. Globe and angle refrigerant valves shall have either forged brass or bronze alloy bodies, be back-seating type, and shall have packed stem and seal cap. Valves 7/8 inch outside diameter and smaller shall be packless type having handwheels and bodies with brazing ends. Bonnets shall be replaceable while the valve is in place. Valves shall be rated for 450 psig maximum working pressure and 275 degrees Fahrenheit maximum operating temperature.

3. Check Valves Smaller Than 7/8 inch: 500 psig maximum operating pressure, 300 degrees Fahrenheit maximum operating temperature; cast brass body, with removable piston, Teflon seat, and stainless steel spring; straight through globe design. Valve shall be straight through pattern, with solder-end connections.

4. Provide relief and safety refrigerant valves with forged brass bodies; nonferrous, corrosion-resistant internal working parts; and either female threaded or brazing connections.

5. Solenoid Valves: Complete valve assembly shall be tested and shall be listed by a nationally recognized laboratory and shall be designed to conform to ARI 760. Solenoid valves shall be 250 degrees Fahrenheit temperature rated, 400 psig working pressure; forged brass, with Teflon valve seat, two-way straight through pattern, and solder end connections. Provide manual operator to open valve. Furnish complete with NEMA 1 solenoid enclosure with one half inch conduit adapter, and 24 V ac, 60 Hz, normally closed holding coil.

D. Fittings: Wrought-Copper Fittings, ANSI B16.22 and ANSI B16.26, as applicable, streamlined pattern.

E. Strainers:

1. Provide single type strainer with brass body 500 psig maximum working pressure. Indicate direction of flow permanently on the body. Provide flange and bolt screen cover for strainers one inch and larger. Screen cover for strainers smaller than one inch shall be flanged and bolted or screwed.

2. Provide strainer body of a size which will provide storage area for foreign material without contributing to excessive pressure drop. Free area of the screen shall be minimum five times the area of the strainer inlet pipe.

3. Screen mesh size shall be not less than 80 for one inch diameter liquid refrigerant lines, and not less than 60 for other liquid refrigerant lines. Screen mesh size shall be not more than 40 for refrigerant suction lines.

4. Reinforce strainer screens with eight or ten wire mesh screen. Strainers may be an integral part of the expansion valve. Braze strainer and screen joints with silver solder.

F. Refrigerant Driers:

1. Provide solid desiccant type drier conforming to ARI 710. Driers 50 cubic inches and larger shall be cartridge refillable type, with a valved bypass of the same size as the liquid line.

2. Provide drier body of brass, capable of holding the desiccant securely in place and distributing the liquid refrigerant evenly throughout the desiccant, and capable of withstanding a test pressure of 350 psig.

G. Moisture Indicators: Moisture indicators shall contain material that shall indicate degree of moisture by color. Indicators shall be either brass, bronze, or heavily copper-plated steel. Locate indicating material under a bull's-eye. Design indicators to withstand a 350 psi test pressure.

H. Sight Glasses: Provide double-port, see-through type sight glass having two bull's-eyes of nonferrous material. Design sight glass to withstand a 350 psig test pressure. Sight glass body shall be either forged brass or bronze, with flanged fittings as specified for piping.

I. Expansion Valves: Provide bronze valves, suitable for silver-soldered joints, and of external equalizer design, conforming with ARI 750, as applicable. Provide valve capillary tubes of lengths required and a distributor with side connection for hot gas bypass line.

J. Hot Gas Bypass Valve: Provide adjustable type, sized to provide capacity reduction beyond the last step of compressor unloading; and wrought copper fittings for solder and connections.

K. Vibration Eliminators: Provide flexible bellows tube type vibration eliminators with seamless tin bronze or stainless steel core. Provide with the following features and services: high tensile bronze braid covering, solder connections, pressure tested, dehydrated, minimum 500 psig working pressure, UL-labeled, minimum seven inches in length.

2.02 REFRIGERANT

A. Provide refrigerant with EPA approved low ozone depletion potential and low global warming potential refrigerants, except as otherwise indicated. Components exposed to refrigerant shall be compatible with refrigerant. Components shall be completely charged. Provide additional charge if required for low ambient control.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install refrigerant piping in accordance with ASHRAE 15.

B. Cut refrigerant piping accurately to measurements established at the site, and install without springing or forcing. Installed piping shall be sufficiently flexible to allow expansion and contraction caused by temperature fluctuation inherent in its operation.

C. Do not conceal piping in walls and partitions, underground, or under a floor, except as indicated. Do not conceal pipe joints within the building. Run insulated pipe as indicated and as required, with sufficient clearance to permit application of insulation. Run piping as indicated, care shall be taken to avoid interference with other piping. Run piping plumb and straight.

D. Refrigerant piping shall be joined by brazing. Free the inside of tubing and fittings from burrs and flux. Clean the parts to be jointed thoroughly with emery cloth. Heat to a temperature greater than the solder flow point, and keep heated until the solder has penetrated the full depth of the fitting and the extra flux has been expelled.

E. Joints shall be air cooled, and flame marks and traces of flux shall be removed. During the brazing operation, protect the piping from forming an oxide film on the inside.

F. Install refrigerant lines in a manner so that the velocity in the evaporator suction line will move the oil and gas to the compressor. Oils shall be automatically returned on halocarbon systems. If equipment location requires a vertical riser, provide riser of a size so that the oil will be lifted at minimum system loading and corresponding reduction of gas volume. Install a double riser if excess velocity and pressure drop would result from full system loading. Provide the larger riser with a trap, of minimum volume, formed by 90-degree and 45-degree ells. Arrange the small riser with inlet close to bottom of horizontal line, and connecting to top of upper horizontal line. Do not install valves in risers.

G. Slope refrigerant piping as follows:

1. Install horizontal hot gas discharge piping with one half inch per 10 feet downward slope away from the compressor.

2. Install horizontal suction lines with one half inch per 10 feet downward slope to the compressor, with no long traps or dead ends which may cause oil to separate from the suction gas and return to the compressor in damaging slugs.

3. Install traps and double risers where indicated, and where required to entrain oil in vertical runs.

4. Liquid lines may be installed level.

H. Install refrigerant driers, sight glass liquid indicators, moisture indicators, and strainers in refrigerant piping if not furnished by the equipment manufacturer as part of the air-conditioning equipment. Install driers in liquid lines, with service valves and valved bypass line. Install driers 50 cubic inches and larger, vertically. Provide cover for removing cartridge at the bottom of the drier.

I. Install moisture indicators in the liquid line downstream of the drier.

J. Locate strainers near the equipment requiring protection. Install a strainer in the common refrigerant liquid supply to two or more thermal valves in parallel if each thermal valve has a built-in strainer. Install strainers with screen down and in direction of flow as indicated on strainer body.

K. Install refrigerant charging valve connection for each remote type refrigeration system, located on the reducing outlet of a full size tee in the liquid line, upstream from the refrigerant drier and liquid indicator sight glass.

L. Install solenoid valves in horizontal lines, locate stems vertically, and indicate direction of flow on the valves. If not incorporated as integral part of the solenoid valve, install strainers upstream of the solenoid valve.

3.02 CLEANING

A. Before installation of copper tubing, clean the tubing and fittings using the following cleaning method and procedure:

1. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through the tubing by means of a wire or an electrician's tape.

2. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.

3. Draw a clean, lintless cloth, saturated with compressor oil, squeezed dry, through the tube or pipe to remove remaining lint. Inspect tube or pipe visually for remaining dirt or lint.

4. Finally, draw a clean, dry, lintless cloth through the tube or pipe.

3.03 TESTS

A. Test piping system under the observation of the Engineer until found to be leak free. Perform tests as follows:

1. Upon completion of factory-fabricated and field-refrigerant piping installation, test piping with either a halide torch or electronic-type leak detector. If leaks are detected during the warranty period, remove the entire refrigerant charge from the system, correct the leaks, recharge the system, and retest.

2. After the system is found to be without leaks, perform the evacuation with a gage and a vacuum pump capable of pulling a vacuum not less than one mm Hg absolute. Perform system evacuation in accordance with either the triple-evacuation and blotter method or the equipment manufacturer's instructions. System leak testing, evacuation, dehydration, and charging with refrigerant shall conform to ANSI B31.5.

3. Refrigerant piping system, including its safety and automatic control instruments, shall be started up and initially operated for not less than eight hours.

B. Use testing instruments calibrated by a qualified laboratory in accordance with Section 01 45 00, Quality Control.

3.04 COMMISSIONING

A. Charge system using the following procedure:

1. Install core in filter dryer after leak test but before evacuation.

2. Evacuate refrigerant system with vacuum pump; until temperature of 35 degrees Fahrenheit is indicated on vacuum dehydration indicator.

3. During evacuation, apply heat to pockets, elbows, and low spots in piping.

4. Maintain vacuum on system for minimum of five hours after closing valve between vacuum pump and system.

5. Break vacuum with refrigerant gas, allow pressure to build up to two psig.

6. Complete charging of system, using new filter dryer core in charging line. Provide full operating charge.

B. Provide training of the District's personnel on procedures and schedules related to start-up and shut-down, troubleshooting, servicing, and preventative maintenance of refrigerant piping valves and refrigerant piping specialties in accordance with Section 01 79 00, Demonstration and Training.

END OF SECTION 23 23 00

SECTION 23 31 00

HVAC DUCTS AND CASINGS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Sheet metal ductwork.

B. Registers, grilles, and diffusers.

C. Electric duct heaters.

D. Manual volume dampers.

E. Fire dampers.

F. Combination fire/smoke dampers.

G. Backdraft dampers.

H. Access doors.

I. Hangers and supports.

J. Sealants.

K. Duct plenums.

L. Flexible connections.

M. Air extractor.

N. Turning vanes.

O. Casings.

P. Fibrous glass ducts.

Q. Kitchen hood exhaust ductwork.

1.02 RELATED SECTIONS

A. Section 01 33 00, Submittal Procedures.

B. Section 01 33 23, Shop Drawings, Product Data, and Samples.

C. Section 01 78 23, Operation and Maintenance Data.

D. Section 07 90 00, Joint Protection.

E. Section 08 31 00, Access Doors and Panels.

F. Section 09 91 00, Painting.

G. Section 20 30 13, Vibration Isolation and Seismic Control.

H. Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.

I. Section 23 81 00, Unitary HVAC Equipment.

1.03 MEASUREMENT AND PAYMENT

A. Separate measurement or payment will not be made for the Work required under this Section. Costs in connection with the Work specified herein shall be considered to be included as part of the Contract lump sum price indicated in the Bid Schedule of the Bid Form for the related item or items of Work.

1.04 REFERENCES

A. Air Diffusion Council (ADC):

1. AMCA 500 Test Method for Louvers, Dampers and Shutters
2. ADC1062: GRD Test Code for Grilles, Registers and Diffusers
3. ARI 650 Air Outlets and Inlets

B. American Society of Heating, Refrigerating and Air Conditioning Engineers Inc. (ASHRAE):

1. ASHRAE Handbook, HVAC Applications
2. ASHRAE Handbook, Fundamentals
3. ASHRAE Handbook, HVAC Systems and Equipment

C. American Society for Testing and Materials (ASTM):

1. ASTM A36/A36M Specification for Structural Carbon Steel
2. ASTM A90 Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles
3. ASTM A123 Specification for Zinc (Hot Dip Galvanized) Coatings on Iron and Steel Products
4. ASTM A153/A153M Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware
5. ASTMA 525 General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot Dip Process

6. ASTM A653/A653M Specification for Steel Sheet, Zinc Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvanized) by the Hot Dip Process

D. American Welding Society (AWS):

1. AWS D1.1 Structural Welding Code Steel
2. AWS D9.1 Sheet Metal Welding Code

E. National Fire Protection Association (NFPA):

1. NFPA 90A Standard for the Installation of Air Conditioning and Ventilating Systems
2. NFPA 90B Installation of Warm Air Heating and Air Conditioning Systems
3. NFPA 92A Smoke Control System

F. Sheet Metal and Air Conditioning Contractors National Association Inc. (SMACNA):

1. SMACNA Ducted Electric Heat Guide for Air Handling Systems
2. SMACNA Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems
3. SMACNA HVAC Air Duct Leakage Test Manual
4. SMACNA HVAC Duct Construction Standards − Metal and Flexible
5. SMACNA HVAC Systems Duct Design
6. SMACNA HVAC Duct Systems Inspection Guide
7. SMACNA Seismic Restraint Manual Guidelines for Mechanical Systems

G. Underwriters Laboratories Inc. (UL):

1. UL 33 Heat Responsive Links for Fire-Protection Service
2. UL 181 Factory Made Air Ducts and Air Connectors
3. UL 555 Fire Dampers
4. UL 555S Smoke Dampers

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit Shop Drawings showing the following information:

1. Ductwork layout including diffusers, registers, and grilles;
2. Fire damper installation details and locations;
3. Access door installation details and locations;
4. Duct sizes, materials, sheet metal gages, duct reinforcement schedules, duct supports, duct support spacing, and fabrication methods; and
5. Volume dampers, motorized dampers, turning vanes, and extractors, installation details and locations.

C. Product Data: Submit manufacturers' product data and certificates of compliance for specified materials and equipment.

D. Test Reports: Submit certified field test reports verifying successful air duct leak testing.

E. Operation and Maintenance Data: Submit operation and maintenance data, for the equipment provided, in accordance with Section 01 78 23, Operation and Maintenance Data.

1.06 QUALITY ASSURANCE

A. Provide fabricated duct systems complete as shown on drawings. Duct sizes, types, routing, and locations shall be as indicated. Wherever possible, ducts shall use long radius sweep elbows in lieu of internal turning vanes.

B. Ductwork shall conform to the applicable requirements of NFPA 90A and NFPA 90B, SMACNA and ASHRAE Handbooks, the California Mechanical Code, Chapter 10, and the equipment manufacturer's recommendations.

C. Duct sizes shall refer to the inside clear dimensions. No insulating (noise or thermal) materials shall be used on inside of supply or return ducts.

D. Change in duct size or shape necessitated by interference with other work shall be made using sizes of equivalent friction loss.

E. Where pipe, structural member, or other obstruction passes through a duct, provide a streamlined sheet metal collar around member and increase duct size to maintain net area. Fit collar and caulk to make airtight.

F. Galvanized surfaces damaged by welding shall be repaired in accordance with manufacturer's written instructions.

G. Submit detailed fabrication drawings of ductwork showing dimensions, construction, welding, fittings, and configurations, and receive approval prior to start of work.

H. Qualify welding processes and welding operators in accordance with AWS D1.1 for hangers and supports, and AWS D9.1 for sheet metal.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Duct sections shall be covered and stored on skids above grade.

B. Duct sections that come in contact with dirt shall be cleaned inside and outside.

C. Use all means necessary at the site to protect the materials from dirt, dust, moisture, physical abuse before and during the installation. All installed duct work openings shall be covered during the construction period.

1.08 SITE CONDITIONS

A. Inspect surfaces and structures where air distribution and duct system will be installed before the work of this Section begins. Provide surfaces and structures capable of supporting the system and its weight.

B. Coordinate the installation of the air distribution and duct system with other building systems and components so as to avoid conflicts of installation. Drawings are diagrammatic and not necessarily to scale.

PART 2 – PRODUCTS

2.01 SHEET METAL DUCTWORK

A. Ducts shall be designed and constructed in accordance with SMACNA HVAC Systems Duct Design and HVAC Duct Construction Standards of lock forming quality galvanized steel sheet conforming with ASTM A653/A653M, ASTMA525, A527 with zinc coating G90 for each side of sheet, unless otherwise indicated.

B. Ducts embedded in concrete shall be constructed of one fourth inch thick carbon steel plate, and shall be welded in accordance with AWS D1.1. Fabricated ducts shall be hot dip galvanized after fabrication in accordance with ASTM A123 and shall be structurally reinforced. Zinc coating designation shall be G90.

C. Duct fabrication, metal gages, and reinforcement shall conform with the SMACNA HVAC Duct Construction Standards - Metal and Flexible. Pressure classification of sheet metal ducts shall be two inches water gage, negative or positive, as appropriate, except that ductwork in subways shall be classified at six inches of water gage, positive or negative, whichever is more stringent.

D. Provide 300 Series (18-8) stainless steel ductwork for battery room exhaust system and for ductwork passing through battery rooms.

E. Design and fabricate ductwork in accordance with the following requirements:

1. Size round ducts installed in place of rectangular ducts from ASHRAE table of equivalent rectangular and round ducts. No variation of duct configuration or sizes will be permitted without written approval of the Engineer.

2. Duct sizes 19 inches wide and larger that have more than 10 square feet or unbraced panel shall be beaded or cross-broken unless ducts will have insulation covering. This requirement is applicable to 20 gage or less thickness and pressure class of three inches water gage or less. It is not necessary to break or bead all sides unless each duct dimension requires it.

3. Lap metal ducts in direction of airflow. Hammer down edges and slips to leave a smooth duct interior. Seal duct seams and joints in accordance with the California Mechanical Code.

4. Construct tees, bends, and elbows with radius of not less than one and one half times width of duct on centerline. Rectangular elbows shall be avoided, if not possible then airfoil type galvanized steel turning vanes shall be used.

5. Increase duct sizes gradually, not exceeding 15 degrees divergence whenever possible. Maximum divergence upstream of equipment shall be 30 degrees and convergence downstream shall be 45 degrees.

6. Rigidly construct metal ducts with joints air tight, braced and stiffened so as not to breathe, rattle, vibrate, or sag. Caulk duct joints and connections with sealant as ducts are being assembled.

7. Modify ducts where ductwork conflicts with piping and structures. Where modifications result in duct area reductions exceeding 10 percent duct area, split into two ducts maintaining original duct pressure losses.

8. Provide necessary baffling in mixed air plenums to ensure good mixed air temperature with variations of not more than plus or minus two degrees Fahrenheit under operating conditions.

9. Construct plenums of galvanized panels joined by standing seams on outside of casing riveted or bolted on approximately 12 inch centers. Reinforce with steel angles and provide diagonal bracing. Tightly fit at apparatus and seal with sealant.

10. Fabricate continuously welded round and oval duct fittings two gages heavier than duct gages indicated in SMACNA Standard. Joints shall be minimum four inch (100 mm) cemented slip joint, brazed or electric welded. Prime coat welded joints.

11. Provide standard 45 degree lateral wye takeoffs, unless otherwise indicated, where 90 degree conical tee connections may be used.

12. Provide openings in ductwork and casings where required to accommodate thermometers and controllers. Provide pivot tube openings where required for system testing and balancing, complete with metal cap and spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.

13. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.

14. Set plenum doors 6 to 12 inches above floor. Arrange door swings so that fan static pressure holds door in closed position.

15. Where indicated, connect diffusers and registers to ducts with flexible duct. Provide ducts tested and classified by Underwriters Laboratories, Inc., as Class 1 Air Duct, and labeled in accordance with UL 181. Provide flexible duct installed in fully extended condition free of sags and kinks, using only minimum length required to make connection. Single bends shall have inside angles of not less than 90 degrees. Flexible duct shall not be longer than five feet.

16. Do not install duct sealants when temperatures are less than those recommended by sealant manufacturers.

17. Maintain temperatures during and after installation of duct sealants.

2.02 REGISTERS, GRILLES, AND DIFFUSERS

A. Product Requirements:

1. Standard Products: Except as otherwise indicated, provide manufacturer’s standard registers, grilles, and diffusers where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation.

2. Performance: Provide registers, grilles, and diffusers that have, as a minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device as listed in manufacturer’s current catalogs.

3. Ceiling and Wall Compatibility: Provide registers, grilles, and diffusers with border styles that are compatible with walls and ceiling systems, and that are specifically manufactured to fit into ceiling module or wall construction with accurate fit and adequate support. Refer to Contract Drawings and Specifications for types of wall construction and ceiling systems.

4. Painting: Registers, grilles, and diffusers shall be finished with a baked white enamel finish unless otherwise approved. Paint must pass ASTM B117, Corrosive Environments Salt Spray Test, ASTM D870, Water Immersion Test, and ASTM B2794, Reverse Impact Cracking Test.

5. Construction: Registers, grilles, and diffusers shall be factory fabricated of aluminum, plate or extruded. Exposed edges shall be rolled, extruded, or otherwise stiffened. All components shall be product of one manufacturer.

6. Air Distribution: Supply air diffusers and registers shall distribute specified quantity of air evenly over space intended without causing noticeable draft, air movements faster than 50 fpm in occupied zone, or dead spots anywhere in the ventilated area.

7. Sound Ratings: Inlets and outlets shall be sound rated and certified in accordance with ADC1062: GRD, in sound power level, decibels reference 10 - 12 W, in octave bands 2 6. The rated NC sound pressure level index, computed by deducting 8 dB room attenuation, shall not exceed NC 35.

B. Diffusers:

1. Internal parts of each diffuser shall be removable as a unit. Removable parts shall be constructed so that they cannot be reassembled in a manner that will produce an incorrect air distribution pattern. The internal assembly shall be either circular, square, or rectangular and shall be removable and capable of being reassembled without special tools. Sheet metal air duct or plenum connection to diffusers shall be secured in accordance with the diffuser manufacturer's instructions. Sponge rubber or neoprene gasket shall be provided between ceiling and surface mounted diffusers.

2. Provide ceiling diffusers of the rectangular, square, or linear face type as indicated. Diffusers shall be equipped with baffles to provide the air distribution pattern. Provide factory fabricated turning-vanes at each diffuser, branch duct and take off, except where flexible ductwork is used. Vanes shall be removable through the diffuser. Each diffuser shall have a factory fabricated, single key, opposed blade volume damper constructed so that the required air flow can be obtained without affecting the air distribution pattern; the volume damper key operator shall be operable through diffuser face without removing air distribution baffle.

C. Supply Registers: Provide multi-directional-control type register with a factory-fabricated volume damper. Volume dampers shall be group-operated, opposed blade type and shall be key adjustable. Volume damper adjustment shall be made by inserting key through face of register. Operating mechanism shall not project through the register face. Registers shall be provided with sponge rubber or neoprene gaskets between flanges and wall or ceiling.

D. Exhaust and Return Registers: Exhaust and return registers shall be as specified for supply registers herein, except provide exhaust and return registers with a single set of fixed, non see-through, non-directional face blades or louvers having the same appearance as the supply register.

E. Grilles: Grilles shall be as specified for registers, except without volume control dampers. Exhaust outlets for battery rooms shall be constructed of type 316 stainless steel.

2.03 ELECTRIC DUCT HEATERS

A. Electric duct heaters shall be flanged type heaters in accordance with applicable requirements of Section 23 81 00, Unitary HVAC Equipment.

2.04 MANUAL VOLUME DAMPERS

A. Requirements: Provide adjustable balancing dampers of minimum 16 gage galvanized steel construction, conforming with applicable requirements of SMACNA HVAC Duct Construction Standards-Metal and Flexible, with locking quadrants. Manually adjustable balancing dampers shall be provided at points on supply systems where branches are taken from larger ducts and in branch duct to individual diffusers, grilles, and registers, as required for air balancing.

1. Damper axles shall be continuous square rods not smaller than 3/8-inch, with machined ends and bearings at both ends. Damper blades shall not be more than six inches wide by 48 inches long.

2. Single-blade dampers shall be provided for duct sizes up to nine-inches by 30-inches. Multi-blade dampers of opposed blade pattern shall be provided for duct sizes larger than nine-inches by 30-inches.

B. End Bearings: Except in round ductwork 12 inches (300 mm) and smaller, provide end bearings. On multiple blade dampers, provide oil-impregnated nylon or sintered bronze bearings.

C. Quadrants:

1. Provide locking, indicating quadrant regulators on single and multi-blade dampers.

2. On insulated ducts, mount quadrant regulators on stand-off mounting brackets, bases, or adapters.

3. Where rod lengths exceed 30 inches (750 mm) provide regulator at both ends.

D. Splitter Dampers: Provide only where indicated. Splitter dampers shall be constructed of double thickness galvanized steel sheet shaped to streamline and stiffened to avoid vibration. Splitter dampers shall be sized on the basis of straight air volume proportioning, and shall be operated by quadrant operators.

2.05 FIRE DAMPERS

A. Fire dampers shall be UL Class A rating and constructed in accordance with UL 555 and SMACNA Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems. Fusible links on fire dampers shall be constructed in accordance with UL 33. Provide fire dampers in accordance with NFPA 90A where ducts and outlets pass through fire-rated walls, and where indicated. Fire damper assembly shall be complete with required perimeter mounting angles, sleeves, breakaway duct connections, and stainless steel springs, bearings, bushings, and hinges.

B. Fire dampers shall be curtain type and fabricated of galvanized steel, weighted to close and remain in closed position when released by fusible link. Fabricate fire dampers with linkage readily adjustable with damper in open position. Curtain type fire dampers shall have blades retained in a recess so free area of connecting

ductwork is not reduced. Fire dampers shall have the same (or higher) fire rating as the fire rated walls where ducts pass through.

C. Set or select fusible links for 165 degrees Fahrenheit release unless otherwise indicated.

2.06 COMBINATION FIRE/SMOKE DAMPERS

A. Provide fire and smoke combination dampers in accordance with UL 555S, Leakage Class II, with a leakage rating of not more than ten cfm per square foot at one inch water gage pressure differential across closed damper. Provide two position dampers, equipped with an electric damper operator and with firestat that electrically locks damper in a closed position when ambient (duct) temperatures exceed 165 degrees Fahrenheit.

B. Damper shall be capable of interfacing electrically with a smoke detector and remote indicating and control station. Where indicated, provide conventional fusible link connection between damper and operator instead of a firestat.

2.07 BACKDRAFT DAMPERS

A. Provide 16-gage aluminum, multiblade, gravity type, backdraft dampers having balanced parallel action, one half inch steel axles with keyways spaced nine inch centers, with one half inch ball bearings, blades, and flexible vinyl sealing edges. Weighted relief dampers shall be used where it is required to maintain positive pressure by forced air supply and gravity exhaust.

2.08 ACCESS DOORS

A. Provide access doors or panels for maintenance of filters and coils, control dampers, on either side of each fire and smoke damper, and at thermostats, temperature controllers, and other apparatus requiring service and inspection. Locations shall be approved prior to duct fabrication. Fabricate rigid, close-fitting doors of galvanized steel with sealing gaskets and quick fastening locking devices. For insulated ductwork, install minimum one-inch thick insulation with sheet metal cover. Provide two hinges and two sash locks for sizes up to 18 inches high, two hinges and two compression latches with outside and inside handles for sizes up to 24 by 48 inch. Height of access doors shall be four to six inches smaller than the duct dimension by 16 inches wide, but not less than 6 inches by eight inches. Provide an additional hinge for larger sizes. Refer to Section 08 31 00, Access Doors and Panels, for detailed requirements for wall and ceiling mounted access doors and panels to access concealed ducts.

B. Access doors in plenums of air-conditioning systems shall be hinged and furnished with latches operable from both inside and outside. Edges shall rest against neoprene or felt for airtight closure. Plenum access doors shall open to the outside of housing on the fan suction side and to the inside on the fan discharge side.

2.09 HANGERS AND SUPPORTS

A. Requirements: Provide hangers and supports of steel shapes and rods conforming to ASTM A36/A36M, galvanized in accordance with ASTM A123. Hardware for hangers and supports shall be galvanized in accordance with ASTM A153/A153M. Hangers and supports shall be fabricated in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, and SMACNA HVAC Systems Duct Design.

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural steel fasteners appropriate for building materials. Do not use powder-actuated concrete fasteners for lightweight aggregate concretes or for slabs less than 4◦inches thick.

C. Hangers: Galvanized sheet steel, or round, uncoated steel, threaded rod.

D. Straps and Rod Sizes: Conform with Table 4-1 in SMACNA HVAC Duct Construction Standards - Metal and Flexible, for sheet steel width and gage and steel rod diameters.

E. Duct Attachments: Sheet metal screws, blind rivets, or self-drilling, self-tapping metal screws; compatible with duct materials.

F. Longitudinal and Transverse Seismic Bracing of Ductwork: Conform to SMACNA Seismic Restraint Manual Guidelines for Mechanical Systems and ASHRAE Handbook, HVAC Applications, except base the design of restraints on a force equal to 100 percent of the weight of the ductwork acting in either direction.

2.10 SEALANTS

A. Provide as specified in Section 07 90 00, Joint Protection, with sealants conforming to SMACNA HVAC Duct Construction Standards - Metal and Flexible.

B. The sealant must be mildew resistant, non-flammable, and meets NFPA 90A and 90B requirements.

2.11 DUCT PLENUMS

A. Provide duct plenums fabricated in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, Section VI, Equipment and Casings.

2.12 FLEXIBLE CONNECTIONS

A. Provide UL-listed flexible connections conforming to NFPA 90A. Fabric shall be unpainted glass fiber cloth weighing not less than 32 ounces per square yard. Cloth shall be coated with fire resistant neoprene on both sides. Flexible portion shall be 6◦inches long. Perimeter connection on each end shall be three inch wide galvanized sheet steel, and shall be mechanically bonded to the fabric. Fasteners shall be either screws or bolts. Flexible connectors shall be mechanically secured, at both ends, to provide airtight joints.

2.13 AIR EXTRACTOR

A. Where more than one outlet is installed in a duct, and where there is inadequate space for installing multi-blade volume damper, an air extractor with locking adjustable quadrant shall be provided, just upstream of each outlet, for noise control and proper diversion of air flow to outlets further downstream. Air extractors shall be movable blade pivoted type. No extractor is required for the last outlet of the system. Extractor and quadrants shall be constructed of galvanized steel.

2.14 TURNING VANES

A. Fabricated Turning Vanes: Provide fabricated single blade, sheet metal turning vanes and vane runners, constructed in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible.

B. Manufactured Turning Vanes: Provide single blade, sheet metal turning vanes constructed of 1-1/2 inches wide curved blades set at 3/4 inch on centers, supported with bars perpendicular to blades set at two inches on centers, and set into side strips suitable for mounting in ductwork.

2.15 CASINGS

A. Fabricate casings in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible and construct for operating pressures indicated.

B. Mount floor mounted casings on four-inch (100 mm) high concrete curbs. At floor, rivet panels on eight-inch (200 mm) centers to angles. Where floors are acoustically insulated, provide liner of 18 gage (1.20) galvanized expanded metal mesh, supported at 12-inch (300 mm) centers, turned up 12 inches (300 mm) at sides with sheet metal shields.

C. Reinforce door frames with steel angles tied to horizontal and vertical plenum supporting angles. Install hinged access doors where indicated or required for access to equipment for cleaning and inspection. Provide clear wire glass observation ports, minimum six-inch by six-inch (150 x 150 mm) size.

D. Fabricate acoustic casings with reinforcing turned inward. Provide 16 gage (1.50 mm) back facing and 22 gage (0.80 mm) perforated front facing with 3/32 inch (2.4 mm) diameter holes on 5/32-inch (4 mm) centers. Construct panels 3 inches (75 mm) thick packed with 4.5 lb/cu ft (72 kg/cu m) minimum glass fiber media, on inverted channels of 16 gage (1.50 mm).

2.16 FIBROUS GLASS DUCTS

A. Fabricate in accordance with SMACNA Duct Construction Standards, except as indicated.

B. Machine-fabricate fibrous glass duct and fittings. Make only minor on site manual adjustments.

C. Staple duct joints and tape with two-inch (50 mm) wide by 3-mil (0.75 mm) thick aluminum pressure sensitive tape, UL approved.

D. Do not use fibrous glass ducts within 12 inches (300 mm) of electric or fuel fired heaters.

2.17 KITCHEN HOOD EXHAUST DUCTWORK

A. Fabricate in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible and NFPA 96.

B. Construct of 16 gage (1.37 mm) carbon steel or 18 gage (1.09 mm) stainless steel, using continuous external welded joints.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Installation Standards: Ductwork and accessories shall be installed in accordance with NFPA 90A, ASHRAE Handbook, and SMACNA HVAC Duct Construction Standards - Metal and Flexible, as applicable. Mounting and supporting of equipment, ducts, accessories, and appurtenances shall be provided, including structural supports, hangers, stands, clamps, and brackets. Equipment shall be installed in accordance with the manufacturer's installation instructions.

B. Sheet Metal Ductwork:

1. Ductwork shall be installed in accordance with the Contract Drawings and approved Shop Drawings. Sections to be installed shall be cleaned of dirt, dust, and debris before installation.

2. Elbows, turning vanes, take offs, branch connections, transitions, splitters, duct volume dampers, fire dampers, combination fire and smoke dampers, flexible connectors, and access doors shall conform with SMACNA HVAC Duct Construction Standards - Metal and Flexible, SMACNA Ducted Electric Heat Guide for Air Handling Systems, and SMACNA Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems, as applicable.

3. Field changes to ductwork, such as those required to suit the size of factory fabricated equipment, shall minimize losses in pressure and performance caused by sudden expansion and contraction. Transitions shall be used in field changes as well as modifications to connecting ducts.

4. Locking type quadrant operators for dampers, installed on ducts to be thermally insulated, shall have stand off mounting brackets, bases or adapters to allow for a clearance not less than the thickness of the insulation between duct surface and the operator. Stand off mounting items shall be integral with the operator or standard accessory of the damper manufacturer. Locking devices shall be located on ends of actuator arms, as far as possible from pivot point of dampers.

5. Install backdraft dampers in the discharge duct of exhaust fans and where indicated except in battery room exhaust duct system.

6. Duct sleeves and prepared openings shall be provided where ducts penetrate floors, walls, ceilings or roofs, and shall be installed during construction of the floor, wall, ceiling or roof. Branch take off connections shall be provided in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible.

7. Duct sleeves shall be fabricated from minimum 20 gage galvanized sheet steel. Sleeve shall have one inch clearance between the duct and the sleeve, or one inch clearance between the insulation and the sleeve for insulated ducts. Duct sleeves embedded in concrete shall be one fourth inch plate in accordance with Article 2.01.B, herein.

8. Duct penetrations through fire rated walls and floors shall meet requirements imposed by the jurisdictional Fire Marshal if more restrictive than the specified SMACNA requirements.

9. Prepared openings shall have one inch clearance between the duct and the opening, or 1 inch clearance between the insulation and the opening for insulated ducts, except at grilles, registers, and diffusers.

10. Closure collar shall be not less than four inches wide, and shall be installed on each side of walls or floors where sleeves or prepared openings are provided. The collar shall be installed against the surface of the wall or floor. The edges of the collar shall be ground smooth. Collars shall be fabricated from minimum 20 gage galvanized sheet steel for ducts with a maximum side of 15 inches, and from minimum 18 gage galvanized sheet steel for ducts with a side of over 15 inches.

11. Space between the sleeve or opening and the duct or duct insulation shall be packed airtight with felt, neoprene, or plastic sealing strips.

C. Duct Hangers and Supports:

1. Install duct hangers and supports spaced on each side of duct in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible. Supports on risers shall allow free vertical movement of the duct. Duct shall be installed and supported so as to be completely free from vibration and sagging under all conditions of operation.

2. Supports shall be attached only to structural framing members or concrete beams and slabs. Where supports are required between structural framing members, intermediate metal framing shall be provided. Where C clamps are installed, retainer clips shall be installed.

3. Ducts shall be seismically restrained in accordance with requirements of Section 20 30 13, Vibration Isolation and Seismic Control for Facility Services.

4. Hangers and devices in exterior locations exposed to the weather shall be painted with corrosion-resistant paint as specified in Section 09 91 00, Painting.

D. Registers, Grilles, and Diffusers: Registers, grilles, and diffusers shall be installed only after all ceilings and walls are finished including final painting. Ceiling mounted units shall be installed with rims tight against ceiling. Wall mounted units shall be installed at least 6 inches below the ceiling unless otherwise indicated. Dampers provided with diffusers and registers shall not be used for system balancing. Inside of duct, behind see-through registers and grilles shall be painted black.

E. Flexible Connections: Provide flexible connections located between fans and ducts and casings and ducts of dissimilar metals.

F. Flashings: Provide flashings where ducts pass through exterior building walls and roofs. Flashings shall weatherproof the penetration.

G. Duct Heaters: Where electric heaters are installed in air ducts, the duct shall be insulated with noncombustible insulation extending in each direction from the heater. Distance shall be as recommended by the heater manufacturer.

3.02 CLEANING

A. After completion of ductwork, the entire system shall be cleaned of rubbish, plaster, dirt, dust, and other debris. After equipment has been installed and connections have been made, and before grilles, outlets, and registers are installed, the entire system shall be blown out with dampers and outlets wide open. Temporary screens or filters shall be provided to protect equipment during the cleaning operation.

3.03 FIELD QUALITY CONTROL

A. Ductwork and accessories shall be leak tested before installing insulation. Tests shall be performed in accordance with and at the maximum pressure designation of SMACNA HVAC Air Duct Leakage Test Manual. Joints and seams shall be tested in the presence of the Engineer.

B. Determine leakage from entire system or section of the system by relating leakage to the surface area of the test section.

C. Maximum allowable leakage shall be as specified in ASHRAE Handbook, Fundamentals, “Duct Design”. Comply with requirements for leakage classification three for round and flat oval duct, leakage classification 12 for rectangular, duct in pressure classifications less than and equal to two inches water gage (both positive and negative pressures), and leakage classification six for pressure classifications greater than two inches water gage and less than and equal to 10 inches water gage.

D. Remake leaking joints as required and apply sealants to achieve tight joints with less leakage than the maximum allowable leakage.

E. Perform volumetric measurements and adjust air systems as specified in ASHRAE Handbook, HVAC Systems and Equipment; ASHRAE Handbook, HVAC Applications; ASHRAE Handbook, Fundamentals; and Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.

F. Perform inspections, as necessary, to ensure compliance with NFPA standards and SMACNA HVAC Duct Construction Standards - Metal and Flexible, witnessed by the Engineer. Conduct inspection in accordance with SMACNA HVAC Duct Systems Inspection Guide. Results of inspections shall be documented and submitted for review.

G. After testing and inspection, system shall be restored to its operating condition.

3.04 ADJUSTING AND BALANCING

A. Refer to Section 23 05 93, Testing, Adjusting, and Balancing for HVAC, for requirements and procedures for adjusting and balancing air distribution and return systems.

END OF SECTION 23 31 00

SECTION 23 31 14

DUCTWORK FOR TUNNEL VENTILATION

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. The work of this Contract Specifications Section includes furnishing, installing, and testing of Ventilation System Accessories as shown on the Contract Drawings, including the ductwork, flexible connections, screens, and all structural support elements and hardware for the installation of equipment.

1.02 RELATED SECTIONS

A. Section 23 33 14, Dampers for Tunnel Ventilation

B. Section 23 33 20, Sound Attenuators for Tunnel Ventilation

C. Section 23 34 14, Fan Motor Units for Tunnel Ventilation

1.03 MEASUREMENT AND PAYMENT

A. General: Separate measurement or payment will not be made for the work required under this Section. All costs in connection with the Work specified herein will be considered to be included or incidental to the Work of this Contract.

1.04 REFERENCES

A. Where materials or equipment are required to conform to referenced industry standards, the current edition of the most recent revisions as of the date of Notice to Proceed shall apply.

B. Contractor may propose for approval alternate standards to those listed herein, provided that the standards are submitted in the English language, with a point-by-point comparison between the specified and alternate standards included in the submittal. The requirements of proposed alternate standards shall be at least as stringent as the specified standards.

C. Reference Standards:

1. American Iron and Steel Institute (AISI):
    a. Type 316, Stainless Steel.
2. American National Standards Institute (ANSI):
    a. C1, General Requirements of a Quality Program.

3. ASTM International (ASTM):

    a. A 36, Carbon Structural Steel.

    b. A 123, Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

    c. A 193, Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service.

    d. A 194, Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service.

    e. A 239, Locating the Thinnest Spot in Zinc (Galvanized) Coating on Iron or Steel Articles.

    f. A 276, Stainless Steel Bars and Shapes.

    g. A 666, Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate and Flat Bar for Structural Applications.

    h. A 780, Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.

4. American Welding Society (AWS):

    a. AWS B5.1, Specification for the Qualification of Welding Inspectors.

    b. D1.1, Structural Welding Code - Steel.

    c. D1.3, Structural Welding Code - Sheet Steel.

    d. D19.0, Welding Zinc-Coated Steels.

    e. QC1, Standard for AWS Certification of Welding Inspectors.

5. National Fire Protection Association (NFPA):

    a. 90A, Installation of Air Conditioning and Ventilating Systems.

    b. 130, Standard for Fixed Guideway Transit and Passenger Rail Systems.

6. Sheet Metal and Air Conditioning Contractor’s National Association Inc. (SMACNA):

    a. Rectangular Industrial Duct Construction Standards, I-P Second Edition.

    b. Round Industrial Duct Construction Standards.

7. Steel Structures Painting Council (SSPC):

    a. PA-1, No. 1 Shop, Field and Maintenance Painting.

8. Underwriter's Laboratories, Inc. (UL)

1.05 SYSTEM DESCRIPTION

A. Design Temperature Conditions: Ductwork and accessories shall be selected and designed to permit continuous operation at an ambient temperature of not less than 482 degrees Fahrenheit.

B. Design Pressure Conditions: Ductwork and accessories shall be capable of withstanding the stresses caused by pressure transients from train piston action, and by reversal of airflow. The ductwork and accessories shall withstand a differential pressure of 14 inches water gauge from atmospheric conditions, or fan shut-off pressure (resulting from possible operation of the ventilation fan against a closed damper), whichever is higher. Coordinate with fan manufacturer to establish maximum fan shut-off pressure.

C. Critical Load Conditions: The design of ductwork, attenuator exterior casings, and fan-to-duct transitions shall account for the largest total load that the ductwork, attenuator exterior casings and transitions will be subjected to under the various operating conditions described in Article 2.02 herein.

1.06 SUBMITTALS

A. Provide submittals in accordance with Contract Specifications Section 01 33 00, Submittal Procedures, Contract Specifications Section 01 33 23, Shop Drawings, Product Data, and Samples, Contract Specifications Section 01 42 19, Reference Standards, and the requirements herein. In case of conflict, the more stringent requirement shall take precedence.

B. The Contractor shall submit the following:

1. Certified Shop Drawings, including Bill of Materials, for fan ductwork, flexible connections, and screens; installation drawings, installation instructions; dimensioned drawings for installation of structural steel members (columns, mullions, lintels, and other structural support members) to be furnished by manufacturer; weight of components and additional components and data required for proper installation.

2. Certificate of Compliance signifying that equipment to be furnished under this Contract meets the requirements specified herein.

3. List of technical support items specified and list of additional support items required.

1.07 QUALITY CONTROL

A. Welding: All Components in this Contract requiring welding shall be welded as follows:

1. Code Requirement: Welding shall conform to the requirements of AWS D1.1 and AWS D1.3.

2. Welder Qualification: Welders welding on the work of this Contract shall be qualified in accordance with the requirements of AWS D1.1.

3. Welding Inspections:

   a. Visual Inspection: All welds shall be visually examined in accordance with AWS D1.1, Section 6 and 7.8, as applicable. Quality of welds and standards of acceptance shall be in accordance with AWS D1.1, Sections 8.15.1, 9.25.1, and 10.17.1, as applicable.

   b. All shop and field welding for Station ventilation fan system ductwork shall be visually inspected and approved by an independent inspection or testing laboratory, or technical consultant. The inspector shall be an independent Certified Welding Inspector (CWI) who has met the qualification and program requirements of the American Welding Society (AWS) to certify welding inspectors, as specified in AWS QC1 and the requirements of 5.2, 6.1, and 6.2 of AWS B5.1.

   c. The CWI shall file an inspection results report with the District Representative.

   d. The welding shall be subject to inspection and tests in the shop and in the field. Inspections shall be made prior to galvanizing, painting, or otherwise finishing of the welded materials. Inspection in the shop will not relieve the Contractor of the responsibility to furnish welds of satisfactory quality.

   e. When inspection indicates defects in the weld joints, the welds shall be repaired using a qualified welder or welding operator as applicable. Corrections shall be made in accordance with the requirements of AWS D1.1/D1.1M. Corrections and repairs shall be made at no additional cost to the District Representative or its agents.

   f. All welds are subject to inspections and tests by the District Representative. Welds to be inspected and tested by the District Representative will be selected at random.

1.08 STORAGE AND PROTECTION

A. Storage: Store all materials and equipment in dry, ventilated, weather tight enclosures.

B. Protecting Machined Surfaces: Apply a rust preventive on machined surfaces such as flanges and shafts. Use material of a type that is easily removable with solvent during equipment installation.

C. Protecting Openings: Close pipe connections, ends, and other openings with easily removable plugs, stoppers, or flange covers.

1.09 CONTRACT/JOBSITE CONDITION

A. Surfaces and structures to which the products will be affixed, placed, and installed shall be inspected by Contractor in the presence of the equipment manufacturer and the District Representative before the work begins. Surfaces that will be concealed by products shall be finished before products are installed.

PART 2 – PRODUCTS

2.01 DUCTWORK, CASINGS AND TRANSITIONS

A. General

1. Ductwork and attenuator exterior casings, fan-to-duct transitions and all parts thereof shall be capable of withstanding the thermal expansion and operational stresses under Design Temperature Conditions. All ductwork, plenums, fans, dampers, intake airshafts and/or discharge air shafts and any related materials or equipment in the airflow path related to the emergency ventilation system shall be constructed of materials that will provide a minimum fire-resistance rating of at least two (2) hours.

2. Ductwork and attenuator exterior casings shall be fabricated of hot-rolled steel in conformance with the requirements of ASTM A-36 with minimum thickness is accordance with the requirements of SMACNA Rectangular or Round Industrial Duct Construction Standards Section 6.6.1 Duct Selection Tables and shall have companion flanges at both ends. Fan-to-duct transitions shall be fabricated of hot-rolled steel not less than the gauge of the connecting ductwork or attenuator casings and shall have companion flanges at both ends. Ductwork, attenuator exterior casings and fan-to-duct transitions shall be hot-dip galvanized after companion flanges and all additional reinforcement and stiffeners have been welded in place.

3. Ductwork, attenuator exterior casings, and fan-to-duct transitions shall be designed in accordance with SMACNA Rectangular or Round Industrial Duct Construction Standards, and shall be capable of withstanding the critical load for each ventilation fan system without deformation, excessive deflection, or panel vibrations in excess of 50 percent of panel metal thickness. The critical load shall be the largest total load that the ductwork will be subjected to under the various operating conditions described in Article 2.02 herein. In accordance with the SMACNA definitions Stiffeners and Supports are different. Stiffeners act as beams and Supports act as columns. The use of internal bracing is not allowed. Neither Supports nor Stiffeners shall be utilized inside of the ductwork, attenuator exterior casing, fan-to-duct transitions or other parts of the duct system.

4. Ductwork, attenuator exterior casings and fan-to-duct transitions shall be fabricated in multiple sections.

5. All transverse joints used for the connection of ductwork and attenuator exterior casings and fan-to-duct transition sections shall be flanged, gasketed, and bolted together to form an airtight perimeter. Flanges shall be fabricated of galvanized steel structural channels in conformance with ASTM A-36 and sized in accordance with the requirements of SMACNA Rectangular Industrial Duct Construction Standards Section 6.7 Auxiliary Tables 6-B2 through 6-B20, but no less than the minimum flange height specified in Table 6-G1. Transverse joints shall be SMACNA Standard Figure 11-3, type E, with the exception that a continuous weld shall be used in every location in the SMACNA figure that indicates use of a stitch weld.

6. The minimum size of bolts to be used for the connection of ductwork and attenuator exterior casing and fan-to-duct transition sections shall be in accordance with the requirements of SMACNA Rectangular Industrial Duct Construction Standards Table 6-G1.

7. The maximum bolt pitch, or spacing between the bolts, to be used for the connection of ductwork and attenuator exterior casing and fan-to-duct transition sections shall be in accordance with the requirements of SMACNA Rectangular Industrial Duct Construction Standards Table 6-G1. Bolt holes shall be equally spaced and symmetrical across the length of each companion flange. The maximum distance from each end of the companion flange to each end bolt hole shall be one-half of the actual bolt hole pitch.

8. The maximum bolt hole gauge, or distance from the surface of the duct, attenuator casing panel, or fan-to-duct transition section surface to the centerline of the bolt hole in the companion flange, shall be as in accordance with the requirements of the SMACNA Rectangular Industrial Duct Construction Standards Table 6-G2.

9. All ductwork and attenuator exterior casing panel longitudinal seams (those seams connecting the top end side panels or sheets to each other) shall be of the continuous welded type only. Longitudinal seams shall be one of the following types: SMACNA Standard Figure 11-1, type A, B, C, D, E, F, and Figure 11-2, type G, H, I, and including the welded seam that is labeled type J, with the exception that a continuous weld shall be used in every location in the SMACNA figures that indicates use of a stitch weld.

10. Non-welded longitudinal seams of any type shall not be permitted for ductwork and attenuator exterior casings. SMACNA standard Figure 11-2, type K, L, and the grooved seam pipe lock also tagged as type J shall be specifically excluded from use on this Contract.

11. Flanged, gasketed, and bolted longitudinal seams (those seams aligned with the airflow direction) shall be permitted for fan-to-duct transitions, and shall be constructed as shown in SMACNA Standard Figure 11-3, Type E, with the exception that a continuous weld shall be used in every location in the SMACNA figure that indicates use of a stitch weld.

12. Covering or obscuring of welded ductwork seams with any miscellaneous materials which are not part of the ductwork construction, as indicated in the SMACNA standards shall not be permitted. Any such materials that are installed shall be removed and the ductwork surfaces repaired.

13. Each ductwork and attenuator exterior casing section shall be match-marked with stencils in a conspicuous location for identification at the Jobsite. The sections shall be of such size that can be brought into the fan rooms or to their installation locations through the access provided and to facilitate handling, erection, and disassembly.

14. Ductwork and attenuator exterior casings shall be reinforced with exterior mounted stiffeners designed in accordance with SMACNA Rectangular Industrial Duct Construction Standards Section 6.7 Auxiliary Tables 6-B2 through 6-B20, and shall be capable of withstanding the critical load for each emergency ventilation system without deformation or excessive deflection and to limit ductwork panel vibration to not more than 60 percent of ductwork panel metal thickness during fan-motor unit operation. The critical load shall be the largest total load that the ductwork will be subjected to under the various operating conditions described in Article 2.02B herein.

15. Steel for ductwork, attenuator exterior casing, and fan-to-duct transition reinforcement stiffeners and the companion flanges shall be single lengths of structural bar, angle, channel, or beam sections, conforming to the requirements of ASTM A-36. The companion flanges shall also act as stiffeners, and shall be designed to meet the same critical loads as the stiffeners. Companion flanges and stiffeners shall be continuous and shall extend around the entire exterior perimeter of the ductwork and the attenuator casings. Companion flanges for rectangular ducts shall be structural steel conforming with the requirements of ASTM A-36. Companion flanges shall be sized to match the flanges of the duct, flexible connection, or fan casing which is being connected. Contractor shall coordinate all of the companion flange sizes for all system components. Stiffeners or supports mounted inside of the ductwork are not acceptable. Stiffeners and companion flanges spliced together from shorter lengths of the required structural sections shall not be permitted. Stiffeners and companion flanges shall be protected by an additional coating of zinc-rich paint after installation.

16. Terminating ends of reinforcing stiffeners shall be rounded or beveled.

17. The steel sheets that will form the ductwork, attenuator exterior casing, fan-to-duct transition sections and the structural steel sections to be used as companion flanges shall be cut to the required sizes, the holes for the connecting bolts shall be punched or drilled into the companion flanges, and the companion flanges welded to the ends of each duct and casing panel prior to hot-dip galvanizing the assembled panel.

18. Contractor shall comply with the requirements of AWS D19.0 calling for welds to be made on surfaces free of lead and zinc, and shall coordinate with the hot-dip galvanizing vendor to mask those portions of the duct and casing panels that shall be subjected to further welding operations during assembly of the ductwork and attenuator casings. This includes, but is not limited to, the locations of the intermediate stiffeners, hanger frames, and the edges of the panels to be welded to form the longitudinal seams. Contractor shall restore the protective coating of all system components when welding and assembly are completed, in compliance with the requirements of ASTM A 780-01, to build a zinc-rich film to the thickness required by the standard.

19. Access doors shall be the flanged frame type, constructed in accordance with the SMACNA standard, Figure 11-11. Each door opening shall be framed with structural steel sections continuously welded to the duct surface. Access doors shall be double panel doors with the outer panel forming an air-tight seal with the frame, and the inner panel shall be flush with surface of the duct to reduce air pressure losses and turbulence. Access doors shall be of the same material as ductwork and shall be provided where indicated. Each access door shall have a clear opening size not less than 48 inches by 48 inches, or largest size practical in smaller ducts. Access doors shall be provided with not less than 1/4 inch thick silicone gaskets to ensure airtight construction. Access doors shall be provided with wedge type latches, and welded Type 316 stainless steel flat bar hinges. Handhold bar shall be provided above top of access door.

20. Contractor shall provide a 1/4 inch thick silicone gasket between all adjacent companion flanges; width of gaskets shall be same as flange width. Gaskets shall be capable of withstanding Design Temperature Conditions without emitting toxic or noxious fumes.

21. Transitions shall be designed in accordance with AMCA 210 Except as noted. The shape of the transition elements shall be limited to 15 degrees converging and diverging.

2.02 CRITICAL LOADS

A. The critical load used for designing the ductwork and attenuator exterior casings, and fan-to-duct transitions shall be the greatest of the loads following operating conditions:

1. Fan shut-off condition: Fan(s) on; system air pressure equal to the fan shutoff pressure (resulting from possible operation of the ventilation fan against a closed damper); normal ambient temperatures, less than 120 degrees Fahrenheit; no maintenance load.

2. Emergency operation condition: Fan(s) on; fan total pressure equal to the values indicated in the Ventilation Fan Schedule, operating at 482 degrees Fahrenheit; no maintenance load.

3. Maintenance operation condition: Fan(s) off; system air pressure equal ambient pressure; normal ambient temperatures less than 120 degrees Fahrenheit; maintenance load applied to horizontal surfaces as described below.

B. Critical Load Calculation Components

1. Operating pressure: Operating pressure shall be defined as 5.1 inches water gauge differential pressure. For purposes of these calculations, operating pressure shall be applied as a positive pressure to the lower duct and attenuator panels and a negative pressure to the upper panels for horizontal fan and duct orientation. Both positive and negative operating pressure shall be considered for calculation of critical loads for side panels for vertical fan and duct orientation.

2. Train passage pressure: Train passage pressure, resulting from pressure transients generated by passage of trains, shall be defined as a minimum cycling value of plus or minus 14.0 inches water gauge differential pressure. For purposes of these calculations, operating pressure shall be applied as a positive pressure to the lower duct and attenuator panels and a negative pressure to the upper panels for horizontal fan and duct orientation. Both positive and negative operating pressure shall be considered for calculation of critical loads for side panels for vertical fan and duct orientation.

3. Shut-off pressure: Shut-off pressure, resulting from possible operation of the Station ventilation fan(s) against a closed damper(s), shall be defined as the greater of either the actual shutoff pressure of the fans to be provided by the contractor for each emergency ventilation system, or a minimum value of 14.0 inches water gauge differential pressure. For purposes of these calculations, operating pressure shall be applied as a positive pressure to the lower duct and attenuator panels and a negative pressure to the upper panels for horizontal fan and duct orientation. Both positive and negative operating pressure shall be considered for calculation of critical loads for side panels for vertical fan and duct orientation.

4. Temperature: See Article 2.02A herein.

5. Duct and attenuator casing panel loads: the dead weight of each sheet metal panel shall be included in the calculations as required by the SMACNA Standard.

6. Stiffener and connection flange loads: the dead weight of the stiffeners and connection flanges shall be included in the calculations as required by the SMACNA Standard.

7. Maintenance loads: An allowance for the weight of an installer or a maintenance worker to be on top of or within an emergency ventilation system duct or attenuator casing for horizontal fan and duct orientation shall be included in the critical load calculations as required by the operating conditions described in Article 2.02B herein. The maintenance load is dependent on the assumed weight of the person and tools, and upon the stiffener spacing used for the affected emergency ventilation system component. Calculation of maintenance loads shall be in accordance with SMACNA Rectangular Industrial Duct Construction Standards Section 4.4.2.5.

C. Seismic Criteria: Equipment furnished for this work shall be capable of withstanding the seismic loading in accordance with BART Facilities Standards, Criteria, Structural-Seismic Design, without adverse effect on performance, operation, or life expectancy.

2.03 FLEXIBLE CONNECTIONS

A. Flexible connections shall be as indicated on the Contract Drawings and consist of fabric connector material and fabric securing bars. Flexible connections shall be fabricated from material capable of operating at Design Temperature Conditions without failure.

B. Flexible connections shall be designed to allow sufficient radial, axial, rotational, and lateral movement of Station ventilation fan-motor unit assembly resulting from expansion, contraction, and dynamics of air moving unit operations, without unnecessary slack in fabric connector material.

C. Flexible connections and all components thereof shall be designed to be airtight and provided in accordance with the code requirements of the applicable NFPA 90A.

D. Flexible material shall have a nominal thickness of not less than 1/8-inch; it shall be flame-resistant, abrasion-resistant, and able to withstand, without deleterious effect, saturation with grease and oil. The corners on rectangular flexible connections shall be completely molded and free of splices. The total length of the flexible connection shall be a minimum of 12 inches.

E. Companion flange angles shall be fabricated of Type 316 stainless steel, in accordance with the requirements of ASTM A 276. Companion flanges shall be sized to match the flanges of the duct or equipment which is being connected. Contractor shall coordinate all of the companion flange sizes for all system components.

F. Companion flange angles shall have punched or drilled holes sized to receive the size bolts required by the equipment being connected. The hole pitch, or spacing between the bolts, locations, and the bolt hole gauge, or distance from the duct or casing panel surface to the centerline of the bolt hole in the companion flange, shall match that of the connecting equipment. The companion flanges shall be an integral part of the flexible connection. Contractor shall coordinate all of the companion flange bolt patterns for all system components.

G. The fabric securing bar shall be a minimum of 3/8 inch thick by two inches wide and fabricated from Type 316 stainless steel, chambered or rounded edge bar stock conforming to ASTM A 276 and A 666.

H. Flexible connection flow liner shall be fabricated of Type 316 stainless steel, minimum No. 10 U.S.S. -gauge thickness, in accordance with the requirements of ASTM A 666.

I. Flexible connections shall not be painted or used to correct misalignment.

J. Flexible connections shall be designed in accordance with SMACNA Industrial Duct Construction Standard and shall be capable of withstanding the critical load for each emergency ventilation system. The critical load shall be the largest total load that the ductwork will be subjected to under the various operating conditions described in Article 2.02 herein.

2.04 GUARD SCREENS

A. Unless otherwise specified herein or indicated on the Contact Drawings, guard screens shall be one half inch by one half inch wire mesh fabricated of No. 18 U.S.S. gauge steel wire. The screen shall be reinforced across the shorter dimension with one and one half inch by one and one half inch by No. 10 USS gauge steel angles at midpoint. Guard screen shall be provided with rigid flanges not less than one inch wide fabricated of not less than No. 16 U.S.S. gauge steel, designed for bolting to mating companion flanges. Guard screen, frames and reinforcing angles shall be Type 316 stainless steel in accordance with the requirements of ASTM A 276.

B. Screen frames shall be bolted to companion flanges with bolts spaced not more than 12 inches on center.

2.05 INSTALLATION HARDWARE

A. Fasteners:

1. In accessible areas, fasteners shall be hexagonal head bolts with hexagonal head nuts, washers and heavy-duty lock washers.

2. In inaccessible areas, fasteners shall be hexagonal head tap bolts with suitable flat washers and heavy-duty lock washers.

3. Bolts shall not be less than one half inch in diameter unless otherwise indicated.

4. Hardware shall be stainless steel bolts, nuts, and flat washers. Bolts and tap bolts shall conform to the requirements of ASTM A 193, Grade B8M or B8MA, equivalent to AISI Type 316, with suitable lock washers in accordance with ANSI B18.21.1. Nuts shall be stainless steel and shall conform to the requirements of ASTM A 194, Grade 2H, equivalent to AISI Type 316.

B. Expansion Bolts:

1. Expansion bolts shall be Type 316 stainless steel double element type of not less than 3/4 inch in diameter, with suitable Type 316 stainless steel flat and heavy-duty lock washers.

2. Expansion bolts shall be submitted for approval.

C. Apply coat of dielectric separator, Tnemec 10-99 or approved equivalent, to galvanized steel surfaces in contact with stainless steel hardware and expansion bolts, or use plastic insulators with shoulders to prevent direct contact of stainless steel hardware and expansion bolts with galvanized surfaces.

2.06 SHOP FINISHES

A. All galvanized parts shall have either a hot-dipped or an electro-deposited zinc coating. The weight of the coating shall not be less than two and one half ounces per square foot of surface. The zinc coating shall be applied after the material is fabricated. Galvanized steel angles used for companion flanges, structural support elements, or legs for ductwork and attenuators shall be protected by an additional coating of zinc-rich paint after installation. The galvanizing shall conform to ASTM A 123; and withstand an eight-dip Preece Test in accordance with ASTM A 239.

B. All steel components provided with a hot-dipped galvanized coating shall be sufficiently braced during the galvanizing process to prevent buckling or warping of surfaces.

C. Zinc-rich topcoat paint material shall be applied to galvanized structural steel ductwork and accessories angles in accordance with the paint manufacturer's printed paint application instructions and in accordance with the applicable non-conflicting requirements of SSPC PA-1.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Products shall be installed, aligned, connected, and tested in accordance with approved Shop Drawings, and in accordance with the respective equipment manufacturer's printed installation instructions and under supervision of equipment manufacturer's field service engineer.

B. Contractor shall furnish hardware to companion flange attachment for companion flanges. Hardware shall be as specified herein above.

C. Apply anti-seizing compound to the threads of stainless steel bolts and studs.

D. Use torque wrenches to obtain required bolt tension without applying excessive torque.

E. Galvanized surfaces damaged during shipment, welding or installation and any areas of steel surfaces remaining uncoated after hot-dip galvanizing shall be repaired in accordance with the requirements of ASTM A 780, Standard, to build a zinc-rich film to the thickness required by the standard.

END OF SECTION 23 31 14

SECTION 23 33 14

DAMPERS FOR TUNNEL VENTILATION

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. The work of this Contract Specifications Section includes furnishing, installing, and testing of motor operated dampers and appurtenances as shown on the Contract Drawings for Station and tunnel ventilation.

1.02 RELATED SECTIONS

A. Section 23 09 01, Fan Damper Control Pane;

B. Section 23 31 14, Ductwork for Tunnel Ventilation

C. Section 23 34 14, Fan-Motor Units for Tunnel Ventilation

D. Section 26 05 24, Low Voltage Wires and Cables

1.03 MEASUREMENT AND PAYMENT

A. General: Separate measurement or payment will not be made for the work required under this Section. All costs in connection with the Work specified herein will be considered to be included or incidental to the Work of this Contract.

1.04 REFERENCES

A. Where materials or equipment are required to conform to referenced industry standards, the current edition of the most recent revisions as of the date of Request for Proposals shall apply.

B. Contractor may propose for approval alternate standards to those listed herein, provided that the standards are submitted in the English language, with a point-by-point comparison between the specified and alternate standards included in the submittal. The requirements of proposed alternate standards shall be at least as stringent as the specified standards.

C. Reference Standards:

1. American Iron and Steel Institute (AISI)

2. American National Standards Institute C1 (ANSI)

3. Air Moving and Control Association (AMCA):

   a. 500D, Laboratory Method of Testing Dampers for Rating

   b. 500L, Laboratory Method of Testing Louvers for Rating

c. 510, Methods of Testing Heavy Duty Dampers for Rating

d. 511, Certified Rating Program – Product Rating Manual for Air Control Devices

4. American Society for Quality (ASQ):

a. C1, General Requirements for a Quality Program.

5. American Society of Mechanical Engineers (ASME)

a. B18.21.1, Lock Washers (Inch Series)

6. American Society for Testing and Materials International (ASTM):

a. A36/36M, Specification for Carbon Structural Steel

b. A193, Alloy-Steel and Stainless Steel Bolting Materials for High Temperature and High Pressure Service and Other Special Purpose Applications

c. A194, Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both

d. A240, Chromium and Chromium Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels and for General Applications

e. A276, Stainless Steel Bars and Shapes

f. A588, Specification for High Strength Low Alloy Structural Steel with 50 A588 Mksi (345 MPa) Minimum Field Point to 4 inches (100 mm) Thick

g. A666, Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate and Flat Bar

h. E84 Test Method for Surface Burning Characteristics of Building Materials

7. American Welding Society (AWS):

a. D1.1, Structural Welding Code - Steel.

b. D1.3, Structural Welding Code - Sheet Steel.

8. Institute of Electrical and Electronics Engineers (IEEE)

a. 112, Standard Test Procedure for Polyphase Induction Motors and Generators

9. National Electrical Manufacturer’s Association (NEMA):

a. ICS-2, Industrial Control and Systems Controllers, Contactors, and Overload Relays, not rated more than 2000 volts AC or 750 volts DC.

b. ICS-6, Industrial Controls and Systems Enclosures

c. MG-1, Motors and Generators.

10. National Fire Protection Association (NFPA)

a. 70, National Electric Code (NEC)

b. 130, Standard for Fixed Guideway Transit and Passenger Rail Systems

c. 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.

11. Underwriters Laboratories (UL):

a. 508, Industrial Control Equipment

b. 555, Smoke Dampers

c. 723, Test for Surface Burning Characteristics of Building Materials.

d. 2196, Fire Resistive Cable

1.05 SUBMITTALS

A. Provide submittals in accordance with Contract Specifications Section 01 33 00, Submittal Procedures, Contract Specifications Section 01 33 23, Shop Drawings, Product Data, and Samples, Contract Specifications Section 01 42 19, Reference Standards, and the requirements of Article 1.05 herein. In case of any conflict, the more stringent requirements will take precedence.

B. Within 90 Days after Notice to Proceed, Contractor shall submit names and qualifications of manufacturer of tunnel ventilation dampers for approval; qualification statement shall include but need not be limited to the following data:

1. Theoretical performance curves for dampers proposed to be furnished under this Contract. Performance curves shall be plotted to such scales as will make it possible to read the data accurately.

a. The damper performance characteristic curves shall be as follows:

1) Curve plotted with ordinate as pressure drop in inches of water versus face velocity in feet per minute.

2) Curve plotted with ordinate as duct pressure in inches of water versus leakage in cubic feet per minute (cfm) per square foot of damper.

b. The following information shall be indicated in each performance curve:

1) Contract title.

2) Name and address of damper manufacturer.

3) Name and address of damper operator manufacturer.

4) Contractor’s name and address.

5) Air density.

6) Damper face area.

7) Damper assembly net free area.

8) Damper operator model number.

9) Electrical and mechanical characteristics of damper operator (voltage/phase/frequency).

10) Electrical characteristics of damper operator space heater, including voltage and kilowatt input.

2. Damper manufacturer, damper operator manufacturer and Contractor quality assurance programs shall be in accordance with ANSI C1, AMCA 511 and UL 555S.

3. A complete list of projects on which similar dampers for rail projects or other industrial applications with high temperature requirements in the US have been installed or furnished. List shall include:

   a. Name of authority or user (include the Owner's installations, if any).

   b. Contract number(s).

   c. Original installation date(s).

   d. Number and size of dampers and number of operators.

   e. Current condition of equipment, including estimate of remaining useful life.

   f. A list of all known failures including, their apparent causes, corrective work affected, and a description of equipment service and operating conditions.

4. Manufacturer's certificate of compliance and the results of previous Elevated Temperature Test if conducted for certification of such requirements.

5. List of components proposed to be purchased from other manufacturers (including but not limited to: frame, housing, blades, linkages, bearings, and seals), giving name of manufacturer, type and characteristic of each item.

C. The Contractor shall submit the following for each type of damper to be furnished under this Contract:

1. Certified Shop Drawings including Bill of Materials for dampers and damper operators, installation drawings including damper power and control wiring, interfacing junction boxes and conduits, installation instructions, dimensioned drawings for installation of structural steel members, mounting and anchorage data, and any additional data required to demonstrate compliance with Contract Documents. Weight of damper modules and operators shall be indicated.

2. Catalog cuts for damper operators and limit switches.

3. For each damper size and type provide calculations for the damper torque requirements and the actual operator torque.

4. Gasket data documenting high temperature capability.

5. A detailed analysis to demonstrate that the various damper components at their point of critical stress do not exceed the stress endurance limit of the material. Calculated maximum expected stresses for both the normal design pressure

condition and the test condition, together with design properties of the material used to fabricate the damper blades and shafts, shall be submitted for approval.

6. Certificate of Compliance signifying that equipment to be furnished under the Contract meets the requirements specified herein.

7. Test program plan and schedule.

8. Factory test procedures.

9. Field test procedures.

D. Within 14 Days after successful completion of all factory tests specified herein and of any additional tests conducted at Contractor's own option, Contractor shall submit the following:

1. Certified results for all tests conducted. Actual performance curves verifying the theoretical performance curves previously submitted shall be furnished as part of the damper unit test results. Curves shall include the data specified in Article 1.05A herein. All test data shall be bound in one report. The test report shall be indexed and cross-referenced in an easily understood manner.

2. All records and results of non-destructive examinations made at completion of each examination.

E. Operation and Maintenance Manuals

1. At least 30 Days before shipment of the first damper unit, Contractor shall submit for approval three copies of the preliminary maintenance manual that shall provide technical support for damper maintenance. After approval of the preliminary submittal and having made all necessary corrections and amendments required, Contractor shall provide twenty additional copies of the approved dated Operation and Maintenance (O&M) Manuals. One master camera-ready set shall be included as one of the twenty copies to permit additional copies to be made. The master camera-ready copy shall be clearly marked as such on the outside. An electronic copy of the O&M Manual text, drawing and catalog cut files shall also be provided. The O&M Manual shall provide a clear explanation of the theory, operation, and maintenance of the equipment accompanied by photos and schematic, wiring, and mechanical assembly diagrams, as required. The O&M Manual shall be indexed and cross-referenced in an easily understood manner. The O&M Manual shall be loose-leaf bound and shall include, but not necessarily be limited to, the following information:

a. Operating instructions.

b. Troubleshooting and fault isolation procedures for on-site level repair.

c. Procedures for separately removing and replacing damper motor operator, limit switches and individual damper sections.

d. Damper, damper operator and limit switch disassembly and re-assembly instructions.

e. A list of the components that are replaceable at the three possible levels of maintenance: on-site, District Representative facilities, and manufacturer's facility.

f. A test procedure to verify the adequacy of repair work.

g. A preventive maintenance schedule and instructions detailing lubrication of moving parts.

h. A list of technical support items and special tools provided by Contractor.

i. A list of tools and test equipment required to perform all maintenance tasks.

j. The latest service bulletins with dates which describe service procedures.

k. Contractor shall supply twenty copies of all revisions to service bulletins that are included in the maintenance manuals described herein for a period of five years from date of facility opening for revenue service.

F. Technical Support Items: At least 30 Days before shipment, Contractor shall submit the following:

1. Ten sets of special tools shall be provided in total. Special tools shall be those tools that are required to specifically service or repair the damper unit that is being supplied and that are not normally carried in a general machinist's toolbox.

2. Tabulation of spare parts necessary to maintain the dampers procured under this Contract. This table will become a working document to be used by the District's Representatives in the procurement of support items, and shall be updated as changes occur. The spare part items shall be grouped by equipment and components. This list for each item shall give complete ordering and procurement information for that item, including quantity required to maintain inventory for 500 hours' operation. Each item listed shall contain at least the following information: item name, description rating, estimated operating life, current price, manufacturer's name, part name, and drawing reference number. Items that are common to more than one damper shall be cross-referenced. A column, immediately after the columns indicating recommended spare quantities, shall indicate expected delivery time in excess of 60 Days.

G. Prior to Substantial Completion the Contractor shall submit training materials in accordance with Contract Specifications Section 01 79 00, Demonstration and Training.

H. Prior to Substantial Completion the Contractor shall submit a recommended spare parts list in accordance with Contract Specifications Section 01 78 44, Spare Parts and Maintenance Manuals.

I. Record Drawings: Submit record drawings in accordance with Contract Specifications Section 01 78 39, Contract Record Documents.

J. Prior to Substantial Completion the Contractor shall submit information on the warranty (see Supplementary Conditions Article SC4.7, Guaranty of Work).

1.06 QUALITY CONTROL

A. Welding: All Components in this Contract requiring welding shall be welded as follows:

1. Code Requirement: Welding shall conform to the requirements of AWS D1.1 and AWS D1.3.

2. Welder Qualification: Welders welding on the work of this Contract shall be qualified in accordance with the requirements of AWS D1.1, Section 5, Qualification.

B. Source Quality Control

1. Dampers shall be the product of a single manufacturer whose name shall appear on the theoretical performance curves and other data submitted.

1.07 STORAGE AND PROTECTION

A. Storage: Store all materials and equipment in dry, ventilated, weather tight enclosures.

B. Protecting Machined Surfaces: Apply a rust preventive on machined surfaces such as flanges and shafts. Use material of a type that is easily removable with solvent during equipment installation.

C. Protecting Openings: Close pipe connections, ends, and other openings with easily removable plugs, stoppers, or flange covers.

1.08 CONTRACT/JOBSITE CONDITIONS

A. Design Temperature Conditions: Motor operated dampers shall be designed so that the dampers will be fully operational after exposure to an airstream temperature of not less than 482 degrees Fahrenheit for not less than one hour and an airstream temperature not less than 392 degrees Fahrenheit for not less than two hours (including the one hour at 482 degrees Fahrenheit). Dampers and components shall be capable of withstanding the stresses caused by pressure transient pressures from train piston action, and by reversal of airflow and thermal shock caused by temperature changes of from 0 to plus 482 degrees Fahrenheit.

B. Design Pressure Conditions: Dampers and components shall be capable of withstanding the stresses caused by transient pressures from train piston action, and by reversal of airflow. The motor operators shall be capable of actuating the dampers against a differential pressure cycling between plus and minus 14 inches water gauge, or fan shut-off pressure (resulting from possible operation of the ventilation fan against a closed damper), whichever is higher, across the dampers. Coordinate with fan manufacturer to establish maximum fan shut-off pressure.

1.09 SPARE PARTS

A. Supply the District Representative with four spare damper operators for each size and type of damper operator, identical to the operators installed to operate the dampers. The damper operator motors shall be complete and labeled with the motor characteristics.

B. Supply the District Representative with four spare limit switches of each type identical to those installed.

C. Provide the District Representative with spare damper support bearings. Quantity of damper support bearings shall be 5 percent of each type used on dampers. Store bearings in secure storage containers with permanent labels identifying number, type, manufacturer, bearing location on dampers, and the District Contract Number.

PART 2 – PRODUCTS

2.01 MOTOR OPERATED DAMPERS

A. General Requirements

1. Dampers shall conform to all the regulatory requirements of NFPA 70 and NFPA 130 where applicable.

2. Dampers shall be furnished complete with damper mounting frames for each damper section and all components, including operators and limit switches, and; with all structural support elements and hardware required for installation of the damper section into composite damper units in their intended positions, and with any additional accessories which may be needed in order to meet the performance requirements as provided in these Contract Specifications.

3. All like components shall be furnished by a single Supplier.

4. Temporary supports and bracing shall be provided to maintain damper square and rigid at all times during handling and erection.

5. Each damper section module shall have integral channel frames with interconnecting linkage between modules and operators that shall permit all blades in damper section to operate in unison. Modules shall be individually removable from composite assembly. All damper modules shall be surface-mounted against the face of structural steel members (beams, support frames, mullions) or ductwork. Furnish all internal intermediate supports and mullions required for installation of the damper sections into composite damper units.

6. Dampers and damper companion flanges may be fabricated in multiple sections where required. The sections shall be interconnected with bolted splice plates. The damper modules shall be of such size that can be brought into the fan rooms and vent shafts through the access provided and to facilitate handling, erection and disassembly, but not greater than 56 inches in blade length. Before

fabrication, the openings for ventilation dampers and the equipment access shall be field verified.

7. Linkages and bearings of all damper modules shall be arranged in such a manner that they are easily accessible upon removal of gasketed cover plates, without removal of entire damper section.

B. Damper Requirements

1. All motor operated dampers furnished shall be suitable for installation in either a vertical plane or a horizontal plane, as required. Dampers and damper companion flanges shall be as indicated on Contract Drawings and as specified herein.

2. The dampers shall be designed to be assembled and disassembled in the field with special tools as described in Article 1.05E.1 herein from modular panels. Each damper panel shall be of the multiple parallel blade type, with an independent channel frame; and shall be factory-assembled complete with frames, blades, shafts, bearings, seals, linkage, and all accessories required to erect the modular panels into sections and then into composite damper units. Dampers shall be furnished complete with all intermediate support members and hardware required to complete the installation.

3. Multiple modular panel dampers may be operated by use of jack shafting.

4. Dampers shall be special tools arranged for electric motor operation to two blade positions: fully open and fully-closed. Each damper shall be furnished complete with electric motor operators sufficient in number and capacity to actuate all modular panels in a damper section in unison under the operating conditions specified herein. Thermal overload protective devices shall be capable of being overridden during emergency operations. Dampers shall be suitable for continuous operation in either open or closed position.

5. Motor operated dampers shall have a net free face area of not less than 80 percent measured to the inside of the damper frame clear opening when blades are fully open.

6. Upon loss of power, dampers shall have a fail position as shown on the Contract Drawing.

7. Each damper section shall be provided with two blade-position sensing DPDT (double pole, double throw) limit switches for remote indication of the damper position, one for fully open position and one for fully closed position. Switches shall be provided with independent contacts mounted to positively detect full-open and full-closed positions. Limit switches for dampers required to operate in high temperature shall be suitable for operating at Design Temperature Conditions.

8. For multiple section dampers, and dampers that operate in a group, limit switches shall be wired as shown on the Contract Drawings to provide a common open or closed indication for each damper section, or damper group.

9. All power and signal wiring for damper operators and limit switches shall be wired to barrier strips in common weatherproof cast iron terminal box fitted for conduit entry, drilled and tapped for 1-1/2 inch conduit, and mounted on the damper mullion or other suitable position. Control cables shall conform to the requirements of NFPA 130 and as described in Contract Specifications Section 26 05 24, Low Voltage Wires and Cables. If necessary, the terminal box and wiring may be removed for shipment, but the damper manufacturer shall provide adequate instruction for installation and electrical connection in the field. Damper manufacturer shall designate routing and attachment points for all damper-mounted electrical items.

10. In order to meet the requirements of NFPA 130 that covers the tunnel area, all field cables running from the motors junction box and through ducts/plenum up to the Junction Box placed outside the tunnel section shall conform to the requirements of NFPA 130 and as described in Contract Specifications 26 05 24, Low Voltage Wires and Cables.

C. Damper Performance

1. Performance requirements listed below are based on the air density shown on the Contract Drawings.

2. Contractor shall ensure that the damper manufacturer certifies that the dampers comply with UL 555S, Class 1 requirements and that, when the dampers are fully closed and holding against a maximum differential pressure of plus or minus 14 inches water gauge, or fan shut off pressure (resulting from possible operation of the Station ventilation fan against a closed damper), whichever is higher, leakage through the damper assembly will not exceed 16 cfm per square foot of damper. Coordinate with fan manufacturer to establish maximum fan shut-off pressure.

3. With the dampers in the fully open position, and air flowing across the damper at a uniform velocity of 2,000 fpm, the pressure drop across the dampers shall not exceed 0.15 inch water gauge.

4. The dampers and their associated structural supporting systems shall, when the dampers are in the fully closed position, be capable of withstanding a maximum differential pressure across the dampers of 14 inches water gauge for a minimum of 4,000,000 pressure reversal cycles. Contractor shall ensure that the damper manufacturer submits an analysis confirming this capability.

5. Damper and operator shall be capable of being fully cycled (open to close to open, or vice versa) for a minimum of 100,000 cycles before failure occurs. Contractor shall ensure that the damper manufacturer submits a certificate along with test data for the damper model supplied demonstrating this performance. Individual cycle times shall not exceed the duty cycle of the damper operator.

2.02 DAMPER FABRICATION AND COMPONENTS

A. Damper blades shall have an airfoil cross-section and shall be fabricated of Type 316 stainless steel, in accordance with the requirements of ASTM A 240 and A 666.

The width of the blades measured in the direction of airflow shall not be less than 6 inches and shall not be greater than 12 inches. Damper blades in the open position shall not extend beyond the damper frame. Damper blades shall have metal-to-metal overlap in the closed position. Blade edge sealing strips, regardless of their composition, will not be permitted as a substitute for a true blade-to-blade overlap.

B. Damper blade shafts and jackshafts shall be fabricated of stainless steel Type 316, in accordance with the requirements of ASTM A 276 and A 666. Blade shafts shall be stub axles or full-length construction and shall be not less than 3/4 inch in diameter or square. Jackshafts shall be not less than 1 inch in diameter. The design of the damper blade shafts shall incorporate the devices required for locking the blades onto the shafts. Damper blade shaft axis shall always be horizontal.

C. Damper blade deflection, with blade supported by shaft, shall not exceed L/360 of the span length between centers of shaft bearings with damper in closed position while withstanding the maximum combined Design Temperature Conditions and Design Pressure Conditions listed in Article 1.07 herein, and shall not exceed L/180 of the span length between centers of shaft bearings with damper in closed position while withstanding the maximum combined fan shut-off differential pressure (resulting from possible operation of the Station ventilation fan against a closed damper), if it exceeds 14 inches water gauge, and maximum temperature of not less than 482 degrees Fahrenheit. Coordinate with fan manufacturer to establish maximum fan shut-off pressure.

D. The damper blade and shaft assemblies shall be supported at each end by means of carbon-graphite sleeve type bearings, suitable for operating at Design Temperature Conditions. Bearing mounting shall be external to frame.

E. Damper linkage shall be external heavy-duty industrial type, not less than 1/4-inch by ¾ inch flat bars fabricated of stainless steel Type 316, in accordance with the requirements of ASTM A 276 and A 666,. Linkage shall interconnect damper blade shaft crank arms that shall be fabricated of Type 316 stainless steel not less than 3/16 inch thick. The linkage bearings shall be fabricated of reinforced thermoplane or other material suitable for the specified operating conditions, as approved by the District Representative. The linkage brackets shall be side-mounted and mechanically interconnected with the shafts. Blade shaft crank arms to be welded to axles. Linkage shall be capable of transmitting a minimum of 150 percent of operator load. All linkage parts and assemblies shall be accessible for maintenance and repair after final assembly. A turnbuckle linkage adjustment shall be provided with each linkage to provide a convenient means of adjusting the length of the connecting rod and thereby the damper closure. Linkage elements shall be sized so that the maximum deflection of any element when subjected to the Design Temperature and Pressure conditions specified in Article 1.07 herein shall not exceed L/360, where “L” is the length.

F. Damper frames shall be a channel cross-section with not less than a 12-inch web and a three-inch flange on the mounting side and two-inch flange on the opposite side and shall be fabricated of stainless steel Type 316, in accordance with the requirements of ASTM A 240, A 276 and A 666, with a minimum thickness of 3/16 inch. The corners of the frames shall be welded and reinforced by means of riveted gusset plates.

G. Motor operated dampers shall be furnished complete with all structural support elements necessary for the installation of the dampers, including the following: all intermediate supports, both horizontal and vertical; all clip angles and other framing members as required at the head, sill, mullion and jambs of each damper assembly; and all screws, bolts, nuts, washers and other hardware required to complete the installation. All intermediate supports and framing members required for assembly and installation of the damper modules shall be fabricated of stainless steel Type 316, in accordance with the requirements of ASTM A 240, A 276 and A 666.

H. Lifting lugs shall be of the same material as the exterior damper frame not less than 3/8 inch-thick steel and shall be welded on exterior of damper frame in sufficient number to facilitate future on-site installation and removal. Lugs shall be a minimum of four per each knocked down damper component or frame and spaced to prevent deformation of component when suspended from chains during installation.

I. Mullion supports shall be designed by Contractor. The mullions shall be the full length and width of the dampers. Mullion supports shall be of stainless steel Type 316, fabricated in accordance with the requirements of ASTM A 240, A 276 and A 666, and shall have punched or drilled holes, equally spaced for damper module attachments. Number of damper mullion support holes and space between the holes shall be selected by Contractor.

J. Damper companion flanges shall have punched or drilled holes equally spaced not more than 12 inches on centers.

K. Damper Hardware

1. Positive locking devices shall be provided for all nuts and bolts located within the airstream.

2. In accessible areas, fasteners shall be hexagonal head bolts with hexagonal nuts, provided with heavy-duty lock washers.

3. In inaccessible areas, fasteners shall be hexagonal head tap bolts, provided with heavy-duty lock washers.

4. Bolts shall be not less than one half inch in diameter unless otherwise indicated.

5. Bolts shall be stainless steel and shall conform to the requirements of ASTM A 193, Grade B8M or Grade B8MA, equivalent to AISI Type 316, with suitable lock washers conforming to ASME B18.21.1. Lock washers shall be stainless steel, equivalent to American Iron and Steel Institute (AISI) Type 316.

6. Nuts shall be stainless steel and conform to the requirements of ASTM A 194, Grade 2H, equivalent to American Iron and Steel Institute (AISI) Type 316.

7. All other damper hardware, including, but not limited to clevis pins, cotter pins, groove pins, nut retaining wire, and spacers shall be stainless steel Type 316.

L. Dampers shall be fastened to damper intermediate supports and mullions, by means of stainless steel Type 316 fasteners, type and size as indicated on the Contract Drawings and as specified herein.

M. Damper operator mounting brackets shall be fabricated of not less than 3/8-inch-thick stainless steel Type 316 and shall be bolted to the mounting surface. Mounting bracket shall be constructed in such a manner that bracket cannot be moved by hand to cause binding or misalignment of bearing(s) and damper shaft(s).

N. Damper blade stops and jamb seals shall be fabricated from stainless steel Type 316.

O. Contractor shall provide a one fourth inch-thick silicone base gasket covering the full width of each flange between damper frames and damper companion frames and between damper frames and other associated companion flanges. Gasket material shall be suitable for exposure to Design Temperature Conditions without emitting toxic or noxious fumes. Submit data for approval documenting high temperature capability.

P. The initial charge of lubricants for damper components shall be supplied by the damper manufacturer.

2.03 DAMPER OPERATOR REQUIREMENTS

A. The damper operators shall be electrical type only. Electro-hydraulic operators shall not be used. The motor operators shall be capable of actuating the dampers against the Design Pressure Conditions Article1.08B herein. The operators shall be capable of changing the position of the dampers from fully closed to fully open, or from fully open to fully closed within a period of not more than 10 seconds. The operators shall be selected and their required quantity shall be determined, such that the normal torque output required for each damper or damper section does not exceed two thirds of the rated operator capacity. This selection criterion provides that each operator has at least 50 percent excess capacity. However, in no case shall there be less than two motor operators provided per damper installation. Motor operators shall be able to operate continuously open or closed under the specified Design Temperature Conditions and Pressure Conditions listed in Article 1.08 herein. Dampers shall be able to cycle (open and close) continuously for one hour under the specified conditions. Linkage from the damper operator shall be fabricated of stainless steel Type 316 and shall be connected to the interconnecting blade linkage with a stainless steel Type 316 pin, such that full force of operator is applied to the blade connecting linkage.

B. The motors shall be totally enclosed and wound for one third horsepower maximum, 120-volt, single phase, 60-Hertz alternating current in conformance with NEMA MG-1. The motor windings and motor leads shall be copper and shall be so insulated that the temperature rise of the insulated motor windings shall not exceed 176 degrees Fahrenheit measured by resistance method, above an ambient temperature of 104 degrees Fahrenheit (giving a maximum winding temperature of 280 degrees Fahrenheit).

C. Thermal protective overload devices shall be provided with a bypass for emergency conditions. The thermal protective overload bypass shall be provided with leads terminated in the conduit box.

D. Motors shall be equipped with factory-installed resistance space heaters within the motor enclosure in accordance with NEMA IS1.1 to prevent condensation of moisture in the motor windings. The heaters shall be provided with leads terminated in the conduit box. The heaters shall operate on 120 volts, single phase.

E. Where indicated, upon loss of power to the motor operators, Dampers shall be designed to have a fail position as shown on the Contract Drawings.

F. Damper operators shall be furnished with auxiliary limit switches that meet the requirements of NEMA ICS-6 at both ends of the motor travel. These limit switches are in addition to the limit switches specified in Article 2.01B.7 herein. Each switch shall have a minimum of two sets of single-pole contacts, one normally open and one normally closed; single-throw contacts will be acceptable, provided that the circuits are electrically separate and fully insulated to permit their use on opposite polarities. The contacts shall have an electrical rating of not less than 5 amperes at 120-volt, 60-Hertz alternating current.

G. Motor leads and limit switch contacts shall be factory-wired to cast iron weatherproof terminal boxes fitted for conduit entry. Power, control and heater wiring shall be as specified in Contract Specifications Division 26. Control cables shall conform to the requirements of NFPA 130 and as described in Contract Specifications Section 26 05 24, Low Voltage Wires and Cables. Conduit boxes shall have tightly fitting, gasketed covers designed to resist the entrance of dust and fluids; and shall have threaded conduit openings. All electrical components, conduit and boxes shall be weatherproof. Conduit boxes shall be mounted to the motor mounting plates.

H. Damper motor operators shall be located as shown on the Contract Drawings.

2.04 DAMPER FINISHING

A. Damper Finish: Mill.

2.05 NAMEPLATES

A. Each damper shall be provided with a stainless steel Type 316 nameplate permanently stamped with the name and address of the manufacturer, Manufacturer's model type, serial number and the District's designated damper number.

B. Each damper operator shall be provided with stainless steel Type 316 nameplate permanently stamped with the Contract title, name of Contractor, name and address of the manufacturer, the motor horsepower, voltage, phase, frequency, insulation type, full-load current, locked-rotor current indicating code letters, the design temperature rise over ambient of the motor, the terminal connection chart for the motor, rating of the space heater, speed in revolutions per minute, motor type,

service factor, motor serial numbers, bearing numbers and shop order number and the District's designated damper number.

C. Nameplates shall be attached to respective component in a location conspicuous after installation with stainless steel Type 316 fasteners.

2.06 FACTORY DAMPER TESTS

A. The District may, at his option, witness any or all of the tests specified herein. Contractor shall notify the District Representative, in writing, not less than 4 weeks in advance as to the location and dates of the factory tests.

B. One test sample damper unit not less than 42 inches by 42 inches shall be subjected to tests. The test shall be conducted in a test facility located either at the manufacturer's plant, or at a suitably equipped testing laboratory. The test facility shall be approved by the District Representative.

C. Performance Tests: The sample damper shall be tested in accordance with the latest edition of AMCA 500, using a test set-up approved by the District Representative as appropriate for the intended installation of the dampers. Test data shall be recorded on AMCA data submittal forms, or the equivalent thereof as approved by the District Representative. Certified test data, and certified performance curves for all of the coordinates specified in these Contract Specifications shall be submitted to the District Representative for approval. Conduct the following performance tests:

1. Leakage Test: Measure maximum leakage in cfm per square foot of damper with Design Pressure Conditions.

2. Pressure Drop Test: Measure maximum pressure drop across damper in fully open position with a uniform face velocity of 2,000 fpm.

3. Blade Deflection Test: Measure actual deflection of the damper blade at the point of critical stress. This is shall not exceed the calculated deflection.

D. Operational Test: The damper, while remaining in the fully closed position, shall be subject to not less than 30 pressure reversals in one hour under Design Pressure Conditions. Damper shall still be operational with no visible damage or distortion to any components at the end of the test.

E. If test has not previously been performed to provide data specified in Article 2.01, C.5 herein, conduct test to demonstrate that damper and operator are capable of being fully cycled (open to close to open, or vice versa) for a minimum of 100,000 cycles before failure occurs. Individual cycle times shall not exceed damper duty cycle.

F. Elevated Temperature Test: One damper module and operator shall be subjected to an elevated temperature of not less than 482 degrees Fahrenheit for 1 hour and a temperature of not less than 392 degrees Fahrenheit for two hours. The damper shall be powered open and closed at the beginning of the test period, and every 10 minutes thereafter for the first hour, while subjected to a temperature of not less than

482 degrees Fahrenheit. At the end of one hour, the damper shall remain subjected to an elevated temperature of not less than 392 degrees Fahrenheit for an additional hour with the damper powered open and closed every 10 minutes during the second hour. At the end of the second hour of the test, the damper shall be powered open and closed for 10 cycles. The damper and operator shall operate without failure throughout the entire high temperature test. This test may be waived if the damper manufacturer can demonstrate to the approval of the District that the identical model damper and identical model operator combination have passed an elevated temperature test on previous projects.

G. Each damper assembly shall be satisfactorily operated by its damper operators before delivery.

PART 3 – EXECUTION

3.01 INSTALLERS

A. The District Representative shall be advised in writing of the name and title of the proposed field service engineer, who upon District Representative approval shall have complete authority to represent and to act for Contractor.

B. The manufacturer's field service engineer shall assist the Contractor with the installation of the dampers.

3.02 EXAMINATION

A. Surfaces and structures to which the products will be affixed, placed, and installed shall be inspected by Contractor in the presence of the equipment manufacturer before the work begins. Contractor shall apply finishes to surfaces that will be concealed by the installation of products prior to product installation.

B. Particular attention is called to the fact that nominal dimensions have been indicated on the Contract Drawings for construction of the dampers. However, the actual openings where dampers are to be installed may vary from the indicated dimensions. In providing dampers to close these openings, Contractor shall verify all dimensions in the field and shall design and build each frame to fit the respective opening, without leaving spaces between the frame and structure. All spaces between the frame and the structure shall be filled with grout, neat portland cement or other approved sealing materials, all properly bonded to the existing surface.

C. Prior to installation, the Contractor shall measure or survey the as-built facilities and prepare a layout and section drawing showing the centerline of installation and top of foundation elevations. The horizontal centerline shall be based on the as-built centerline of the tunnel-side opening frame. Vertical control shall be based on the as-built tunnel-side opening frame such that all pieces line up with the tunnel-side opening. Submittal and approval of this layout and section drawing is required before installation can proceed.

D. Contractor shall note any items that may infringe on the necessary clearances for the equipment.

3.03 PREPARATION

A. Ventilation equipment shall be carefully protected at the Jobsite in a manner to preclude the possibility of damage to the equipment.

B. The permanent anti-condensation motor space heaters for the damper motors shall be energized with temporary power before and after installation until permanent power is available. Contractor shall energize the motor space heaters within 24 hours after the damper is delivered to the Jobsite.

C. Equipment shall be located so that working space is available for servicing, replacing, lubricating, and gaining access to controls.

3.04 ERECTION

A. The damper manufacturer's rigging instructions shall be carefully followed.

B. Dampers shall be supported by damper mating frame as indicated on the Contract Drawings.

C. The damper-mounting members shall be secured to the structure using one half-inch concrete anchors, unless otherwise indicated on the Contract Drawings.

3.05 INSTALLATION

A. Dampers shall be installed as indicated on the Contract Drawings. The damper frame shall be bolted to the damper mating frame, with one fourth-inch-thick silicone gasket between, using stainless steel Type 316 fasteners. All fasteners shall be uniformly tightened by means of a torque drive to provide a secure airtight installation.

B. Apply anti-seizing compound to the threads of stainless steel bolts and studs.

C. The operators for each damper shall be mounted as specified herein.

D. All dampers, connecting bars, linkages and operators shall be installed and adjusted so that: when a damper is fully open, the damper blades shall be parallel to airflow to provide minimum pressure loss and obstruction to airflow; when a damper is fully closed, the damper blades shall be perpendicular to the airflow with seals pressing against mating surfaces along their entire length to provide closure to meet leakage requirements.

E. There shall be no flutter, rattling or vibration of damper, connecting bar and linkage either when the damper is operating or when the damper is in the fully open or fully closed positions. Each damper shall be installed so as to provide smooth operation, opening and closing without shock or slamming.

F. All damper linkage shall be properly installed and connected to its respective operator to prevent blade flutter and connecting bar and linkage distortion or binding during operation. Undue flexure or bending of connecting bars and linkage shall be cause for rejection. Such connecting bar and/or linkage shall be replaced with the necessary corrected design, higher strength materials, and proper size of components.

G. After installation and before the start of testing, the equipment shall be lubricated. Equipment shall be checked for clearances and proper alignment.

H. Perform all non-power alignment, adjusting, and testing as required by the manufacturer's installation procedures.

I. Before operating any damper for the first time, by means of the damper operator, Contractor shall manually open and close the damper to verify that there is no blockage of blades, seizure of damper or damper operator, or cause damage to any item of equipment, or injury to personnel.

3.06 ELECTRICAL AND CONTROL

A. All interconnecting power and wiring between ventilation components will be installed, terminated and tested by the Contractor. Contractor shall provide access to equipment and resolve discrepancies in ventilation equipment as required.

B. Inspect all power and control wire connections and perform all continuity testing to ensure proper installation, and meger testing to ensure insulation integrity is maintained after installation is completed. Perform all functional alignment, adjusting, and testing as required by the equipment manufacturer's instructions.

C. When the electrical installation work is completed and verified, advise the District's Representative so that field tests can be performed. After field testing is completed, restore all equipment to its proper operating condition.

D. All power and control wiring external to the ventilation equipment shall be provided by the Contractor.

3.07 FIELD QUALITY CONTROL

A. Equipment shall be installed in accordance with the approved Shop Drawings and the equipment manufacturers' installation instructions and recommendations.

B. All installation procedures shall conform to the equipment manufacturer's instructions. Checklists shall be used and signed off by the responsible installer as well as by the equipment manufacturer's representative.

C. Contractor shall provide the manufacturer's field service engineering and inspection reports to District Representative to confirm that the dampers are properly installed and tested.

D. Field service shall be performed periodically as required during the construction and testing of the District Representative construction contracts. Field service shall not be less than 50 Days.

E. The duties, responsibilities, and qualifications of the field service engineer shall be:

1. Responsible for advising the installation contractors on the proper procedures for the installation of the fan equipment.

2. To have a thorough knowledge of the dampers and the associated systems.

3. To have a thorough knowledge of the test results and performance requirements of all material and equipment supplied.

4. To prepare and submit to the District Representative a written report on the activities and findings for each visit made within 15 Working Days of the visit.

3.08 FIELD TEST

A. Upon completion of the installation of all ventilation equipment and the installation and verification of the power and local control wiring, Contractor shall notify the District Representative in writing at least four weeks before the field testing to have the District Representative present to witness the tests. Contractor shall also notify the field service engineer for assistance in the performance of the tests. Contractor shall be responsible for performing testing of dampers in the field and shall submit field test procedures.

B. Field tests shall be performed under the technical guidance and supervision of the manufacturer's field service engineer. The field service engineer shall provide the field test instrumentation and perform the tests.

C. Electricians to energize the ventilation equipment and make temporary connections where required and assist the field service engineer shall be provided by the Contractor.

D. Visual and operating field test procedures are as follows:

1. Each damper shall be subject to rotation reversal tests. A cycle of rotation reversal is defined as reversal from fully open to fully closed position, and then back to fully open position. Each damper shall require ten cycles of rotation reversal.

2. After completion of reversal tests for tunnel ventilation dampers, each damper operator shall be de-energized and checked to confirm that it will fail in the position as indicated on the Contract Drawings.

E. After completion of all field tests and after the final visit by the field service engineer, Contractor shall submit a field test and inspection report. Field test report shall include copies of raw data, measured results, calculations, and all data derived from tests to confirm compliance with specified performance.

3.09 ADJUSTING:

A. Check operation of internal damper motor operator limit switches to ensure that undue stress is not placed on the damper motor operator when the damper is either fully opened or fully closed.

END OF SECTION 23 33 14

SECTION 23 33 20

SOUND ATTENUATORS FOR TUNNEL VENTILATION

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. The work of this Contract Specifications Section includes furnishing, installing, and testing of Sound Attenuators for Station and tunnel ventilation.

1.02 RELATED SECTIONS

A. Section 23 31 14, Ductwork for Tunnel Ventilation

B. Section 23 34 14, Fan Motor Units for Tunnel Ventilation

1.03 MEASUREMENT AND PAYMENT

A. General: Separate measurement or payment will not be made for the work required under this Section. All costs in connection with the Work specified herein will be considered to be included or incidental to the Work of this Contract.

1.04 REFERENCES

A. Where materials or equipment are required to conform to referenced industry standards, the current edition of the most recent revisions as of the date of Notice to Proceed shall apply.

B. Contractor may propose for approval alternate standards to those listed herein, provided that the standards are submitted in the English language, with a point-by-point comparison between the specified and alternate standards included in the submittal. The requirements of proposed alternate standards shall be at least as stringent as the specified standards.

C. Reference Standards:

1. American Iron and Steel Institute (AISI):
    a. Type 316, Stainless Steel
2. Air Moving and Control Association (ANSI):
    a. C1, General Requirements of a Quality Program
3. American Society of Mechanical Engineers (ASME):
    a. B18.21.1, Lock Washers.
4. ASTM International (ASTM):
    a. A 123, Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

b. A 193, Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service.

c. A 194, Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service.

d. A 239, Locating the Thinnest Spot in Zinc (Galvanized) Coating on Iron or Steel Articles.

e. A 780, Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.

f. E 84, Surface Burning Characteristics of Building Materials.

g. E 477, Measuring Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers.

5. American Welding Society (AWS):

a. AWS B5.1, Specification for the Qualification of Welding Inspectors.

b. D1.1, Structural Welding Code - Steel.

c. D1.3, Structural Welding Code - Sheet Steel.

d. D19.0, Welding Zinc-Coated Steels.

e. QC1, Standard for AWS Certification of Welding Inspectors.

f. Round Industrial Duct Construction Standards.

6. Sheet Metal and Air Conditioning Contractor's National Association Inc. (SMACNA):

a. Rectangular Industrial Duct Construction Standards, I–P Second Edition.

b. Duct Manual & Sheet Metal Construction for Ventilation & Air Conditioning Systems.

7. Steel Structures Painting Council (SSPC):

a. PA-1, No. 1 Shop, Field and Maintenance Painting.

8. Underwriter's Laboratories, Inc. (UL):

a. 181, Factory-Made Air Ducts and Air Connectors.

1.05 DEFINITIONS

A. Attenuator splitter, or baffle, is defined as the part of the sound attenuator that contains acoustic media fill, perforated face sheets, nosing, and any required casing to support the media fill, face sheets and nosing.

B. Attenuator outer casing is defined as a site or factory assembled sheet metal casing into which attenuator splitters are installed on site.

C. Sound attenuating unit is defined as an attenuator outer casing and attenuator splitters assembled on site to form an overall sound attenuator of the dimensions (width/height/length) shown on the Contract Drawings.

D. Attenuator/fan combined sound power level is defined as the maximum specified fan sound power level in decibels minus the specified attenuator insertion loss in decibels. See Contract Drawings for specified fan sound power level and insertion losses.

E. Maximum face velocity is defined as the average cross-sectional velocity, perpendicular to the direction of flow, at flow rate (cubic feet per minute) through the sound-attenuating unit.

F. Maximum static pressure loss is defined as the pressure loss across the sound attenuating unit at the maximum face velocity, based on aerodynamic performance tests in accordance with applicable ASTM, E 477 test codes.

1.06 COORDINATION

A. The sound attenuator manufacturer shall coordinate with the tunnel ventilation fan-motor unit manufacturer to confirm that combined fan/attenuator sound (fan sound power level in decibels minus attenuator dynamic insertion loss in decibels) does not exceed the location and sound level in the Contract Drawings. The sound attenuator manufacturer and the fan-motor unit manufacturer shall jointly provide written certification that the fan-motor units and attenuators have been coordinated to accomplish this.

1.07 SUBMITTALS

A. Provide submittals in accordance with Contract Specifications Section 01 33 00, Submittal Procedures, Contract Specifications Section 01 33 23, Shop Drawings, Product Data, and Samples, Contract Specifications Section 01 42 19, Reference Standards, and the requirements herein. In case of conflict, the more stringent requirement shall take precedence.

B. Within 90 Days after Notice to Proceed, Contractor shall submit names and qualifications of manufacturers of sound attenuators. Such qualification statements shall include, but need not be limited to the following data:

1. Certified performance data of equipment proposed to be furnished under this Contract.

2. Manufacturer's quality assurance programs in accordance with ANSI C1.

3. Complete list of projects on which similar equipment for rail projects or other industrial applications with high temperature requirements in the United States have been installed or furnished. List shall include:

   a. Name of authority or user (Include installations of the Owner, if any).

   b. Contract number(s).

c. Original installation date(s).

d. Current condition of equipment.

e. A list of all known failures including apparent cause(s), corrective work affected, and description of equipment service and operating conditions.

4. List of components to be purchased from other manufacturers. Give name of manufacturer, type and characteristic of each item, and include for each the data requested herein above.

C. The Contractor shall submit the following:

1. Certified Shop Drawings, including Bill of Materials, for sound attenuators; installation drawings, installation instructions; dimensioned drawings for installation of structural steel members (columns, mullions, lintels, and other structural support members) to be furnished by manufacturer; weight of components and additional components and additional data required for proper installation.

2. Certificate of Compliance signifying that equipment to be furnished under this Contract meets the requirements specified herein.

3. List of technical support items specified and list of additional support items required.

4. Attenuator product data, including construction sizes, pressure drop, and acoustical performance data for specified sound attenuators.

5. Attenuator manufacturer's assembly-type Shop Drawings indicating dimensions, weight loadings, required clearances, and methods of assembly of components.

D. Within 14 Days after successful completion of all factory tests specified herein and of any additional tests conducted at Contractor's option, Contractor shall submit the following:

1. Certified results for all tests conducted. All data shall be bound in one report. The test report shall be indexed and cross-referenced in an easily understood manner.

2. All records and results of non-destructive examinations made at completion of each examination.

3. Field sound test procedures.

1.08 QUALITY CONTROL

A. Welding: All Components in this Contract requiring welding shall be welded as follows:

1. Code Requirement: Welding shall conform to the requirements of AWS D1.1 and AWS D1.3.

2. Welder Qualification: Welders welding on the work of this Contract shall be qualified in accordance with the requirements of AWS D1.1.

3. Welding Inspections:

   a. Visual Inspection: All welds shall be visually examined in accordance with AWS D1.1, Sections 6 and 7.8, as applicable. Quality of welds and standards of acceptance shall be in accordance with AWS D1.1, Sections 8.15.1, 9.25.1, and 10.17.1, as applicable.

   b. All shop and field welding for Station ventilation fan system ductwork shall be visually inspected and approved by an independent inspection or testing laboratory, or technical consultant. The inspector shall be an independent Certified Welding Inspector (CWI) who has met the qualification and program requirements of the American Welding Society (AWS) to certify welding inspectors, as specified in QC1 and the requirements of 5.2, 6.1, and 6.2 of AWS B5.1.

   c. The CWI shall submit an inspection results report for approval.

   d. The welding shall be subject to inspection and tests in the shop and in the field. Inspections shall be made prior to galvanizing, painting, or otherwise finishing of the welded materials. Inspection in the shop will not relieve the Contractor of the responsibility to furnish welds of satisfactory quality.

   e. When inspection indicates defects in the weld joints, the welds shall be repaired using a qualified welder or welding operator as applicable. Corrections shall be made in accordance with the requirements of AWS D1.1/D1.1M. Corrections and repairs shall be made at no additional cost to the District.

   f. All welds are subject to inspections and tests and will be selected at random by the District Representative.

1.09 STORAGE AND PROTECTION

A. Storage: Store all materials and equipment in dry, ventilated, weather tight enclosures.

B. Protecting Machined Surfaces: Apply a rust preventive on machined surfaces such as flanges and shafts. Use material of a type that is easily removable with solvent during equipment installation.

C. Protecting Openings: Close pipe connections, ends, and other openings with easily removable plugs, stoppers, or flange covers.

PART 2 – PRODUCTS

2.01 GENERAL

A. Each sound attenuating unit shall be formed from an attenuator outer casing with attenuator splitters

B. Attenuator splitters for use in attenuator outer casings shall be of uniform length. Attenuator splitters total length shall be equal to the overall length of the sound attenuator unit. Divide the length of the attenuator splitters as necessary to provide ease of assembly, installation, support, disassembly, and maintenance. Each length of the divided splitters shall extend over the span of a minimum of two floor supports, and the splitters shall be of sufficiently rigid construction to transfer the weight of the splitters to the floor supports without transferring any of their weight the attenuator outer casings.

C. The pressure loss through each sound attenuator under specified airflow conditions shall not exceed the maximum acceptable values shown in the sound attenuator schedule.

D. Sound attenuators shall provide full octave band dynamic insertion loss (DIL) not less than the values specified in the attenuator performance schedule. The DIL in the 1/3-octave bands containing the fan blade pass frequency and its first harmonic (two times blade pass frequency) shall not be less than the indicated full octave band values. The selection of sound attenuators shall be coordinated with the associated fan design specified in Contract Specifications Section 23 34 14, Fan-Motor Units for Tunnel Ventilation.

2.02 MATERIALS

A. The materials and methods used to fabricate the sound attenuating units shall be selected and designed to permit operation as provided in Article 2.03 Design Temperature Conditions, herein.

B. Attenuator outer casings shall be designed and fabricated in accordance with the requirements of Contract Specifications Section 23 31 14, Ductwork for Tunnel Ventilation.

C. Attenuator splitters shall be formed of not less than No. 18 U.S.S gauge galvanized steel sheet perforated to provide the required acoustic transparency. Perforated face sheets shall be mounted within galvanized steel frames of not less than 16 U.S.S gauge. Face sheets shall be spot welded at not more than three inches on center. Interior partitions shall be located not more than two inches from edge of the attenuator outer casing.

D. Channel spacers built into ductwork outer casings to separate attenuator splitters shall be constructed of not less than No. 16 U.S.S. Gauge galvanized steel in accordance with SMACNA Duct Manual and Sheet Metal Construction for Ventilation and Air Conditioning Systems. Retaining angles used to support

attenuator splitters shall be constructed to withstand the weight of the attenuator module without buckling or deflection.

E. Outer casings shall be sufficiently modularized to allow for ease of disassembly, installation, and re-assembly. Outer casings shall be sufficiently braced with reinforcing angles to limit panel vibrations to not more than 50 percent of panel metal thickness during operation.

F. All longitudinal seams (connecting the side panels or sheets to each other) shall be of the continuous welded type only. Longitudinal seams shall be one of the following types: SMACNA Standard Figure 11-1, types A, B, C, D, E, and F, and Figure 11-2, type G, H, and I, and including the welded seam that is labeled type J, with the exception that a continuous weld shall be used in every location in the SMACNA figures that indicates use of a stitch weld.

G. Non-welded longitudinal seams of any type shall not be permitted. SMACNA standard Figure 11-2, type K, L, and the grooved seam pipe lock also tagged as type J shall be specifically excluded from use on this Contract.

H. Covering or obscuring of welded ductwork seams with any miscellaneous materials which are not part of the ductwork construction, as indicated in the SMACNA standards shall not be permitted. Any such materials that are installed shall be removed and the ductwork surfaces repaired.

I. Contractor shall comply with the requirements of AWS D19.0 calling for welds to be made on surfaces free of lead and zinc, and shall coordinate with the hot-dip galvanizing vendor to mask those portions of the duct and casing panels that shall be subjected to further welding operations during assembly of the ductwork and attenuator casings. This includes, but is not limited to, the locations of the intermediate stiffeners, hanger frames, and the edges of the panels to be welded to form the longitudinal seams. Contractor shall restore the protective coating of all system components when welding and assembly are completed, in compliance with the requirements of ASTM A 780 to build a zinc-rich film to the thickness required by the standard.

J. Sound attenuating units shall be furnished with flanges at both ends, to permit the units to be rigidly bolted to adjacent components. Flanges shall be fabricated of galvanized steel structural channels in conformance with ASTM A123 and shall be bolted to the outer periphery of the casings unless otherwise indicated. Angles shall be protected by an additional coating of zinc-rich paint after installation. Gaskets or sealant, if required, shall be capable of withstanding Design Temperature Conditions Article 2.03A herein without degradation of sealing ability. Flanges shall be sized in accordance with the requirements of SMACNA Rectangular Industrial Duct Construction Standards Section 6.7 Auxiliary Tables 6 B2 through 6-B20, but no less than the minimum flange height specified in Table 6-G1.

K. Filler material shall be inorganic mineral or glass fiber of a density sufficient to obtain the required acoustic performance, and shall be packed under not less than 5 percent compression, to eliminate voids due to vibration and settling. The material shall be inert, vermin-proof, and resistant to high humidity conditions. The

combustion rating of the filler material, when tested in accordance with ASTM E 84 shall be not greater than the following:

1. Flame Spread Classification: 15

2. Smoke-Developed Rating: 0

L. The acoustical fill shall comply with UL 181 for impact and erosion characteristics.

2.03 PERFORMANCE

1. Design Temperature Conditions: Sound attenuating units shall be selected and designed to permit operation for not less than one hour in an ambient temperature of not less than 482 degrees Fahrenheit and not less than two hours in an ambient temperature of not less than 392 degrees Fahrenheit.

2. Design Pressure Conditions: Sound attenuators shall be capable of withstanding the stresses caused by transient pressures from train piston action, and by reversal of airflow. The differential pressure from train piston action cycles between plus and minus 14 inches water gauge. Sound attenuators shall be capable of withstanding the stresses caused by fan shut-off pressure (resulting from possible operation of the ventilation fan against a closed damper. Coordinate with fan vendor to establish maximum fan shut-off pressure.

3. Critical Load Conditions: The design of attenuator exterior casings shall account for the largest total load that the exterior casings will be subjected to under the various operating conditions described in Contract Specifications Section 23 31 14, Ductwork For Tunnel Ventilation Article 2.02.

2.04 CONSTRUCTION

A. Sound attenuating units shall be designed and structurally reinforced in accordance with SMACNA Rectangular Industrial Duct Construction Standards and shall be capable of withstanding the critical load for each emergency ventilation system. The critical load shall be the largest total load that the ductwork will be subjected to under the various operating conditions described in Contract Specifications Section 23 31 14, Ductwork For Tunnel Ventilation, Article 2.02B, under the design pressure conditions described in Article 2.03B herein, air leakage from or into the sound attenuator shall not exceed 10 cubic feet minute per square foot of face area.

B. Sound attenuating units shall be furnished complete with full width structural floor support elements required for installation. Floor support spacing shall be as noted on the Contract Drawings. Structural support elements shall be designed to be bolted to the outer casing of sound-attenuating units, except where noted in the Contract Drawings. All parts of the structural bracing and support elements shall have either a hot-dipped or an electro-deposited zinc coating.

C. Sound attenuating units shall be designed to be readily disassembled and re-assembled in the field, in the event that such disassembly/re-assembly is necessitated by the physical constraints of the installation. Sound-attenuating units

shall be designed to be capable of all operating and performance requirements specified herein, when the elements are disassembled and reassembled in accordance with the explicit, written instruction of the manufacturer of the elements.

D. Continuous metallic nosing fabricated of not less than No. 16 U.S.S. gauge galvanized steel shall be provided to prevent air and sound leakage through the abutting surfaces when the sections are installed in the field to make up one complete sound attenuating unit.

E. Nameplates: Each sound attenuator unit shall be provided with a nameplate fabricated of Type 316 stainless steel not less than No. 10 U.S.S.-gauge thick, permanently stamped with the name and address of the manufacturer, Contractor's identification number, model type, shop order number and serial number and the Owner designated attenuator number. The nameplate shall be securely attached to the exterior of the attenuator unit in a conspicuous location.

2.05 FACTORY TESTING

A. The District Representative may, at his option, witness any or all of the tests specified herein. Contractor shall notify the District Representative, in writing, not less than three weeks in advance as to the location and dates of all factory tests.

B. Before fabrication of sound attenuators to be furnished under this Contract, one sound attenuating duct unit of each type consisting of at least four splitters and a temporary ductwork outer casing, or a test unit having minimum cross-sectional area of 24 inches by 24 inches, shall be factory-tested. The test unit shall represent the full aerodynamic and acoustical design features of the assembled sound attenuator unit. The tests shall be conducted at the operating pressure specified and certified test reports of performance shall be furnished to the Engineer for approval. Factory testing of sound attenuators shall be in accordance with the requirements of ASTM E 477. Test procedures shall be submitted to the District Representative for approval before the factory tests. Test procedure submittal shall also include a dimensional drawing of the attenuator test unit, sample test forms and pass/fail criteria for the test.

C. The required acoustic performance ratings are indicated in the Sound Attenuator Equipment Schedule. The acoustic performance of the test module shall equal or exceed the indicated ratings.

D. The acoustic performance of the test unit shall be determined using a duct-to-reverberant-room test facility that provides for airflow in both directions through the module during the rating procedure. The test facility and rating procedure shall be such, to the satisfaction of the District Representative, that all effects due to end reflection, directivity, flanking transmission, standing waves, and test-chamber sound absorption are eliminated. Acoustic performance ratings shall include in decibels for both forward flow through the test unit (airflow and sound transmission traveling in the same direction), and for reverse flow through the test unit (airflow and sound transmission traveling in opposite directions). The ratings shall be determined with air flowing uniformly over the entering face of the test unit at 2,000 fpm. Acoustic performance data shall be presented in tabular form showing decibels at 8-octave-

band center frequencies from 63 Hertz to 8,000 Hertz, and at the one third-octave band center frequencies containing the fan blade pass frequency and first harmonic.

E. Acoustical-performance of sound attenuating duct elements shall be determined in an acoustical laboratory that is accredited by the National Voluntary Laboratory Accreditation Program (NVLAP) for ASTM E 477 testing. Before proceeding with the performance certification testing, Contractor shall submit for the District Representative approval schematic drawings of the test facility, identifying all test instruments, and test procedures. A copy of the NVLAP accreditation certificate for the test facility shall be included.

F. Aerodynamic performance data shall be determined for the identical test units for which acoustic performance is specified, and under the same conditions of airflow. Airflow measurements shall be made in accordance with the applicable portions of ASTM Standard E 477. Static pressure loss through the test unit at the indicated airflow rate shall not exceed the values indicated in the Sound Attenuator equipment schedule.

2.06 INSTALLATION HARDWARE

A. Fasteners:

1. In accessible areas, fasteners shall be hexagonal head bolts with hexagonal head nuts, washers and heavy-duty lock washers.

2. In inaccessible areas, fasteners shall be hexagonal head tap bolts with suitable flat washers and heavy-duty lock washers.

3. Bolts shall not be less than one half inch in diameter unless otherwise indicated.

4. Hardware shall be stainless steel bolts, nuts, and flat washers. Bolts and tap bolts shall conform to the requirements of ASTM A 193, Grade B8M or B8MA, equivalent to AISI Type 316, with suitable lock washers in accordance with ANSI B18.21.1. Nuts shall be stainless steel and shall conform to the requirements of ASTM A 194, Grade 2H, equivalent to AISI Type 316.

5. Expansion Bolts:

    a. Expansion bolts for bolting sound attenuating units to concrete floor shall be Type 316 stainless steel double element type of not less than three fourths inch in diameter, with suitable Type 316 stainless steel flat and heavy-duty lock washers.

    b. Expansion bolts shall be submitted for approval.

B. Apply coat of dielectric separator, Tnemec 10-99 or equal, to galvanized steel surfaces in contact with stainless steel hardware and expansion bolts, or use plastic insulators with shoulders to prevent direct contact of stainless steel hardware and expansion bolts with galvanized surfaces.

2.07 SHOP FINISHES

A. All galvanized parts shall have either a hot-dipped or an electro-deposited zinc coating. The weight of the coating shall not be less than 2.5 ounces per square foot of surface. The zinc coating shall be applied after the material is fabricated. Galvanized steel angles used for companion flanges, structural support elements, or legs for ductwork and attenuators shall be protected by an additional coating of zinc-rich paint after installation. The galvanizing shall conform to ASTM A 123; and withstand an eight-dip Preece Test in accordance with ASTM A 239.

B. All steel components provided with a hot-dip galvanized coating shall be sufficiently braced during the galvanizing process to prevent buckling or warping of surfaces.

C. Zinc-rich topcoat paint material shall be applied to galvanized structural steel ductwork and sound attenuator angles in accordance with the paint manufacturer's printed paint application instructions and in accordance with the applicable non-conflicting requirements of SSPC PA-1.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Surfaces and structures to which the products will be affixed, placed, and installed shall be inspected by Contractor in the presence of the equipment manufacturer and the District Representative before the work begins. Surfaces that will be concealed by products shall be finished before products are installed.

3.02 INSTALLATION

A. Products shall be installed, aligned, connected, and tested in accordance with approved Shop Drawings, and in accordance with the respective equipment manufacturer's printed installation instructions and under supervision of equipment manufacturer's field service engineer.

B. Apply anti-seizing compound to the threads of stainless steel bolts and studs.

C. Use torque wrenches to obtain required bolt tension without applying excessive torque.

D. Galvanized surfaces damaged during shipment, welding or installation and any areas of steel surfaces remaining uncoated after hot-dip galvanizing shall be repaired in accordance with the requirements of ASTM A 780-01 to build a zinc-rich film to the thickness required by the standard.

3.03 FIELD TESTING

A. The Contractor shall test the noise level after installation in the actual field configuration with the actual fans, dampers and ductwork. The Contractor shall

provide certified documentation detailing the actual noise levels and how the levels compare to the Contract requirements.

END OF SECTION 23 33 20

SECTION 23 34 00

HVAC FANS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Fans-product requirements.

B. Centrifugal utility fans.

C. Tubular centrifugal fans.

D. Axial vane fans.

E. Powered roof exhaust fans.

F. Gravity roof ventilators.

G. In-line cabinet fans.

H. Propeller fans.

I. Wall exhaust fans.

J. Variable air volume units.

1.02 RELATED SECTIONS PRODUCTS

A. Section 01 33 00, Submittal Procedures

B. Section 01 33 23, Shop Drawings, Product Data, and Samples

C. Section 01 78 23, Operation and Maintenance Data

D. Section 01 79 00, Demonstration and Training

E. Section 07 70 00, Roof and Wall Specialties and Accessories

F. Section 20 10 13, Common Materials and Method for Facility Services

G. Section 20 30 13, Vibration Isolation and Seismic Control

H. Section 20 40 13, Identification for Facility Services

I. Section 20 60 13, Motors for Facility Services

J. Section 23 05 93, Testing, Adjusting, and Balancing for HVAC

K. Section 23 81 00, Unitary HVAC Equipment

1.03 MEASUREMENT AND PAYMENT

A. General: Separate measurement or payment will not be made for the work required under this Section All cost in connection with the Work specified herein will be considered to be included or incidental to the Work of this Contract.

1.04 REFERENCES

A. Anti-Friction Bearing Manufacturers Association, Inc. (ABMA):

1. ABMA 9 Load Ratings and Fatigue Life for Ball Bearings
2. ABMA 11 Load Ratings and Fatigue Life for Roller Bearings

B. Air Movement and Control Association (AMCA):

1. AMCA 99 Standards Handbook
2. AMCA 210 Laboratory Methods of Testing Fans for Rating
3. AMCA 300 Reverberant Room Method for Sound Testing of Fans
4. AMCA 301 Methods for Calculating Fan Sound Ratings from Laboratory Test Data
5. AMCA 500D Laboratory Methods Testing for Dampers for Rating
6. AMCA 500L Laboratory Methods Testing for Louvers for Rating

C. Air-Conditioning and Refrigeration Institute (ARI):

1. ARI 410 Standard for Forced-Circulation Air-Cooling and Air-Heating Coils
2. ARI 430 Standard for Central-Station Air-Handling Units.

D. National Electrical Manufacturers Association (NEMA):

1. NEMA MGI Motors and Generators

E. National Fire Protection Association (NFPA):

1. NFPA 70 National Electrical Code
2. NFPA 90A Installation of Air-Conditioning and Ventilating Systems

F. Underwriters Laboratories, Inc. (UL):

1. UL 181 Factory-Made Air Ducts and Air Connectors
2. UL 705 Power Ventilation

1.05 REGULATORY REQUIREMENTS

A. Refer to Section 20 10 13, Common Materials and Methods for Facility Services – Fire Suppression, Plumbing and HVAC, for requirements. Comply with NFPA 70.

1.06 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit assembly, erection, and installation drawings. Include foundation, platform, and curb details as applicable.

C. Product Data: Submit manufacturer's product data for each fan, including fan performance curves, shaft and wheel materials, fan operating efficiency, motor type, coating, sound power ratings for both fan inlet and outlet at rated capacity, electrical characteristics and clearance space for maintenance.

D. Operation and Maintenance Data: Submit manufacturer's operation and maintenance instructions in accordance with Section 01 78 23, Operation and Maintenance Data. Include parts and special tools lists.

E. Test Reports: Submit certified test reports for the fans and field test results for installed products.

F. Submit Foundation Data.

1.07 QUALITY ASSURANCE

A. Sound Power Level Ratings: Comply with AMCA 301. Test fans in accordance with AMCA 300. Fans shall be licensed to bear the AMCA Certified Sound Ratings Seal.

B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings in accordance with AMCA 210.

C. Work Quality: Conform to applicable requirements of AMCA 99.

PART 2 – PRODUCTS

2.01 FANS – PRODUCT REQUIREMENTS

A. General: Provide fans that are factory fabricated and assembled, factory tested, and factory finished, with indicated capacities and characteristics.

B. Fan Wheel: Fan wheels shall be statically and dynamically balanced. Maximum fan wheel tip speeds shall not exceed manufacturer's designed maximum speed for required duty. The wheels shall be designed so that the critical speed is at least 25 percent greater than the maximum design speed.

C. Fan Shaft: Turned, ground, and polished steel, designed to operate at no more than 70 percent of the first critical speed at the top of the speed range of the fan's class. Secure fan wheel and driving pulley to the shaft with keys and set screws.

D. Pulleys: V-belt drive fans shall be provided with an adjustable pitch motor pulley up through 10 HP. Pulleys shall be cast steel sized for a 1.2 service factor. Belts shall be oil resistant, nonsparking, and nonmetric rated for 150 percent of drive motor horsepower. Drive pulley shall be replaced if necessary to have fan deliver required air volume.

E. Belt Guards: Provide galvanized steel belt guards for motors mounted on the outside of the fan cabinet. Belt guards for outdoor units shall be fully enclosed.

F. Shaft Bearings: Provide type indicated, having a median life "Rating Life" ABMA (L50) of 200,000, calculated in accordance with ABMA 9 for ball bearings and ABMA 11 for roller bearings.

G. Motors: Motors shall be premium, highest efficiency, totally enclosed fan cooled in compliance with NEMA MGI and Section 20 60 13, Motors for Facility Services, and shall have electrical ratings as indicated. Motor shall be mounted on adjustable base for belt driven fans. All motors of five HP and above shall have variable speed control.

H. Vibration Isolators: Fan shaft bearing and motor shall be mounted on vibration isolators to structural steel supports, which shall be attached to the fan scroll or frame. Structural steel shall be factory coated with Engineer-approved corrosion-resistant coating system.

I. Fan Nameplates: Provide with each fan indicating area served, cfm, hp, rpm, sp, and size of unit. Nameplates shall be in accordance with Section 20 40 13, Identification for Facility Services.

J. Battery Room Exhaust Fans: Provide with explosion-proof motors and spark-proof construction, AMCA 99-0401, type B. Epoxy coat inside of fan housing.

K. Power ventilators shall comply with UL 705.

L. Dampers and louvers shall be rated in accordance with AMCA 500D and 500L, respectively.

2.02 CENTRIFUGAL UTILITY FANS

A. Provide factory-manufactured, factory assembled, and factory tested centrifugal fans complete with fan wheel, fan shaft, bearings, drive, motor, and accessories as herein specified.

B. Non-overloading type fans shall be of steel construction and shall have fan wheels with backward inclined steel construction with smooth curved inlet flange and airfoil blades combined with a heavy backplate and spun wheel cone. Forward curved type fans, steel construction with inlet flange, backplate, shallowblades with inlet and tip

curved forward in direction of air flow, fan wheels shall have die-cast blades, and venturi style inlet cone. Fan class rating shall not be exceeded.

C. Inlet collars shall extend beyond fan housing sufficiently to provide connection to duct through a flexible connection. Fan inlets shall be double curved and streamlined to provide full smooth airflow to the wheel.

D. Fan outlets shall be provided with removable angles and bolts for attaching flexible connections.

E. Fan housings shall be constructed of heavy gage steel braced to provide stiffness to housing and rigid support for bearings. Housings shall be provided with access panels and drain plugs. Access panels on supply fans located downstream of heating or cooling coils shall be raised type suitable to receive insulation. Housing supports shall be of one-piece welded construction. Removable galvanized steel screens shall be provided for exposed inlet and discharge outlet openings into fan housings including fans in built-up plenums. For the fans operating in the corrosive or dusty environment, the housing shall be epoxy coated.

F. Provide outdoor fans with weather covers for motor and drive. Weather covers shall be provided with ventilation slots, and finished with weather resistant baked enamel. Covers shall be easily removable for inspection and service.

G. Bearings shall be heavy-duty pillow block, self-aligning ball or roller, and antifriction type. Bearings four inches and larger shall have minimum two rows of spherical roller bearings contained in split pillow block, grease-lubricated ball bearing with ABMA 9 (L10 life at 50,000 hours), or roller bearing ABMA 11 (L10 life at 120,000 hours).

H. Shafts: Hot-rolled steel, ground and polished, with keyway, protectively coated with lubricating oil and shaft guard. Provide type 316 stainless steel shafts for corrosive applications.

I. Accessories:

1. Fixed Inlet Vanes: Steel construction with fixed cantilevered inlet guide vanes welded to inlet bell.

2. Adjustable Inlet Vanes: Steel construction with blades (supported at both ends) (cantilevered) with two permanently lubricated bearings, variable mechanism (out of air stream) terminating in single control lever with control shaft for double width fans (and locking quadrant).

3. Discharge Dampers: (Parallel) (Opposed) blade heavy-duty steel damper assembly with blades constructed of two plates formed around and welded to shaft, channel frame, sealed ball bearings, with blades linked out of air stream to single control lever.

4. Inlet/outlet Screens: Galvanized steel, with welded grid.

5. Access Doors: Shaped to conform to scroll, with quick opening latches and gaskets.

6. Scroll Drain: 1/2 inch steel pipe, coupling welded to low point of fan scroll.

7. Provide weatherproof cover for motor and drive where fans are exposed to the weather.

2.03 TUBULAR CENTRIFUGAL FANS

A. Provide factory assembled and tested tubular centrifugal fans complete with fan housing, fan wheel, fan shaft, bearings, drive, motor, and accessories as hereinafter specified.

B. Provide fan wheels having die formed airfoil blades welded to a heavy backplate and spun wheel cone, statically and dynamically balanced.

C. Housing shall be welded tubular steel construction with inlet and outlet flange connection and companion flanges. Fan inlet shall be streamlined with conversion vanes to minimize turbulence and to provide smooth discharge airflow. Removable galvanized steel screens shall be provided for exposed inlets and discharge outlets.

D. Provide pillow-block type ball or roller antifriction type bearings. Motor or fan bearings, drive shaft, and V-belt drive shall be enclosed and isolated from the air stream. Fan bearings shall be sealed against dust and dirt and shall be permanently lubricated with extended lubrication lines to grease fittings outside of the fan housings.

E. Accessories for fans shall be as indicated, with weatherproof covers and bolted access doors.

F. Locate access doors over the wheel in an accessible position, hinged and having latch-type handles; flush mounted for uninsulated housings, raised-mounted for insulated housings.

2.04 AXIAL VANE FANS

A. Axial vane fans shall be V-belt or direct-driven with fixed blades.

B. Housings shall be fabricated from hot-rolled finished steel 14-gage minimum thickness.

C. End flanges shall be continuously welded around periphery of housings. Housings shall be continuously welded, and expanded by mechanical means to ensure concentric forming.

D. Fan rotor hubs and blades shall be cast aluminum. Fan blades airfoil shall be shaped for maximum efficiency and shall vary in twist and width from hub to tip to obtain equal air distribution along blade length. Blade tip clearance to fan housing

shall not exceed 0.05 inch for fan rotor sizes 36 inches and smaller, and 0.1 inch for larger rotor sizes.

E. Critical speed shall be at least 125 percent of maximum design speed. Maximum operating speed shall not exceed 90 percent of maximum design speed and shall not be a whole number derivative of the critical speed or the natural resonance frequency of the blade.

F. Rolled steel companion flanges shall be provided for both ends for connecting sheet metal and flexible duct connectors as required.

G. Manufacturer's standard inlet bell and discharge cone fittings shall be provided where indicated. Inlet bells shall be manufacturer's standard construction material with minimum thickness of 3/32 inch for 36 inch diameter and smaller fans, and minimum thickness of 1/8 inch for fans with diameters larger than 36 inches. Discharge cones shall be steel, 14 gage minimum. Inlet bells shall have drilled flanges for connection to fan flanges.

H. Bearings, motors, and shafts shall be as specified for centrifugal fans.

2.05 POWERED ROOF EXHAUST FANS

A. Unless otherwise indicated, all roof exhaust fans shall have a louvered housing of aluminum construction and a hinged top to allow unrestricted access to fan drive. Louver blades shall incorporate an integral storm-proofing lip. Blades shall be arranged vertically in an extended stacking design beyond the shoulder of the roof curb. Fan housing shall be provided with a factory installed wire mesh aluminum bird screen. Each exhaust fan shall be provided with a self-flashing sound attenuating roof curb.

B. Powered roof exhaust fans shall be silhouette type complete with housing, bird screen, motor, and UL-listed disconnect switch inside the dome housing. Sound attenuating roof curb shall be provided for each fan.

C. Aluminum backdraft damper shall be provided for each exhaust fan as follows:

D. Exhaust fan with louvered housing shall have perimeter type backdraft damper, gravity actuated, aluminum multiple blade construction, felt-edged offset hinge pin, and nylon bearings.

E. Each exhaust fan with spun aluminum housing shall have roof curb base mounted, counterbalanced type backdraft damper, and resiliently mounted motor.

F. Exhaust fans shall be belt-driven or direct-driven as indicated. Motor mounting on belt-driven units shall be adjustable for correction of belt tension. Provide disconnect switch, factory wired, non-fusible, in housing for thermal overload protected motor.

G. Roof Curbs: Provide prefabricated, heavy-gage, galvanized steel; mitered and welded corners; two inch-thick, rigid, fiberglass insulation adhered to inside walls; built-in cant and mounting flange for flat roof decks; and two inch wood nailer. Size as required to suit roof opening and fan base.

2.06 GRAVITY ROOF VENTILATORS

A. Ventilators shall be low silhouette type with a full perimeter hood opening for exhaust relief. Ventilators shall be constructed of extruded aluminum. Hood and extruded structural members shall have stainless steel anchors and fasteners.

A. The ventilator hood shell be constructed of minimum 18 gauge aluminum or 20 gauge galvanized steel.

B. Ventilator shall be designed to have a minimum 1 to 1 ratio of hood perimeter opening to throat area.

C. Each ventilator shall be provided with a wire mesh galvanized steel bird screen and a gravity aluminum backdraft damper. Counterbalanced backdraft damper shall be mounted in throat of ventilator on a continuous extruded aluminum flange.

D. Ventilator hood shall be furnished with hinges to swing open from either side for easy access to backdraft damper. A self-flashing roof curb shall be provided with each gravity roof ventilator.

E. Provide prefabricated roof curbs fabricated from heavy-gage, galvanized steel; mitered and welded corners; two inch-thick, rigid, fiberglass insulation adhered to inside walls; built-in cant and mounting flange for flat roof decks; and two inch wood nailer. Size as required to suit roof opening and ventilator base.

F. Interface and coordinate the work of this Section with the requirements of Section 07 70 00, Roof and Wall Specialties and Accessories.

2.07 IN-LINE CABINET FAN

A. Provide non-overloading type centrifugal fans, with wheel and hub constructed of anodized aluminum.

B. Provide housing containing fan and motor of reinforced steel, phosphatized and prime painted, with interior surfaces lined with acoustical material secured in place. The integral outlet duct shall injection molded from a specially engineered resin exceeding UL requirements for smoke and heat generation.

C. Provide shaded pole type motors connected directly to fan. Provide permanently lubricated sleeve bearings and acoustically isolated mounting bracket. Characteristics and accessories shall be as specified in Section 20 60 13, Motors for Facility Services

D. Provide gravity type backdraft damper integral to housing, with rubber sealed blade secured to a shaft.

E. Motor shall be isolation mounted to a one piece galvanized stamped steel integral motor mount/inlet. A field wiring compartment with disconnect receptacle shall be standard. To accommodate different mounting positions, an adjustable pre-punched mounting bracket shall be provided.

2.08 PROPELLER FANS

A. Propeller fans shall have wheels constructed of either steel or aluminum blades with hubs, mounting rings and plates that are cast or die formed, and with smooth curves where the air enters the wheels.

B. Propeller fans shall be provided complete with motors and fan guards. Fans and motors shall be mounted on resilient supports and heavy steel frame. Steel angles and plates shall be provided to mount fans and dampers in wall openings. Mounting plates shall be designed to prevent distortion and shall be either turned up at edges or braced with steel angles.

C. Shafts for fans shall be steel. Bearings for fan shafts shall be permanently lubricated, permanently sealed, ball bearings.

D. Accepting fan wheels mounted on either extended motor shafts or ball-bearing hubs that rotate on fixed stub shafts, support shafts by two self aligning bearings.

E. Each unit shall be provided with gravity backdraft damper recessed in the wall, with aluminum blades, steel frame, mounted on discharge side of fan, of same manufacturer as fan.

F. Fans shall be belt-driven or direct-driven as indicated. Motor mounting for belt-driven units shall be resilient and shall be adjustable for correction of belt tension.

G. Propeller fan shall have a motor with nameplate rating not less than 10 percent higher than the brake horsepower required to drive the fan with a static pressure 0.20 inch greater than the indicated value. Motors shall be premium, highest efficiency. All motors five HP or greater shall have variable speed controls.

H. Fan guard (motor side) shall be removable 1/2 inch by 1/2 inch galvanized wire mesh screen.

2.09 WALL EXHAUST FANS

A. Wall exhaust fans shall be low silhouette type complete with spun-aluminum housing, wheel guard, disconnect switch, and resiliently mounted motor. Drive assembly shall be mounted on vibration isolators.

B. Ventilator housing shall be spun-aluminum construction and shall be provided with a rubber grommet internal wiring passage. Exhaust air shall discharge in a 360 degree pattern. Fans shall be provided with attachment collar or angle ring to receive through-the-wall sleeve.

C. Fans shall be directly driven backward curved non-overloading centrifugal design.

D. Provide each fan with an aluminum counterbalanced backdraft damper, gravity activated and 1/2 inch mesh thick aluminum wire bird screen unless otherwise indicated.

2.10 VARIABLE AIR VOLUME UNITS

A. Variable air volume units for connection to central air system with hot water or electric heating coils: Each air terminal unit shall be furnished with identification label and air flow indicator, including a unit nominal air flow, maximum factory set air flow, and minimum factory set air flow, and coil type.

B. Basic Assembly:

1. The terminals shall be certified under the ARI Standard 880 and carry the ARI seal. All NC values shall be calculated per ARI Standard 885-98.
2. Casings: Minimum 22 gage (0.8 mm) galvanized steel; maximum casing leakage: one percent of design air flow at three inches (0.624kPa) minimum inlet static pressure
3. Lining: Minimum 3/4 inch (19 mm) thick neoprene or vinyl coated fibrous glass insulation, 1.5 lb/cu ft (24 g/l) density, meeting NFPA 90A requirements and UL 181 erosion requirements.
4. Plenum Air Inlets: Round stub connections for duct attachment.
5. Plenum Air Outlets: S slip and drive connections.

C. Basic Unit:

1. Configuration: Air volume damper assembly and control components inside unit casing.
2. Volume Damper: Constructed of galvanized steel with peripheral gasket and self lubricating bearings; maximum damper leakage: two percent of design air flow at three inches rated inlet static pressure.
3. Mount damper operator to position damper as indicated.

D. Regulator and Damper:

1. Location: Locate air volume damper and automatic flow control assembly inside unit casing.
2. Construction: The damper shall be heavy gauge steel with shaft rotating in self-lubricating bearings. Nylon bearing is not acceptable. Shaft shall be clearly marked on the end to indicate damper position.
3. Automatic Flow Control Assembly: Combine spring rates matched for each volume regulator size with machined dashpot for stable operation.
4. Volume Control Damper: Air volume control damper shall be factory-calibrated assembly, consisting of damper and damper shaft extension for connection to externally mounted control actuator.

E. Multi Outlet Adapter Section: Provide with eight-inch (200 mm) diameter collars, each with butterfly balancing damper with lock.

F. Hot Water Heating Coil shall be in accordance with Section 23 81 00, Unitary HVAC Equipment.

1. Construction: ETL listed and tested in accordance with UL standard 1996 and National Electric Code (NEC), slip-in type, integral control panel and the control box be housed in a NEMA 1 enclosure, factory wired and installed, with:

2. Construction: Hot water coils shall be enclosed in a minimum 20-gauge steel casing allowing attachment to metal ductwork with a slip and drive connection.

3. Capacity: Based on 180 degrees F entering water, 160 degrees leaving water and 50 percent total air volume.

G. Electric Heating Coil shall be in accordance with Section 23 81 00， Unitary HVAC Equipment.

1. Construction: Integral control box factory wired and installed, with:

   a) Primary and secondary over-temperature protection.

   b) Minimum airflow switch.

   c) Electric switches and relays. Magnetic contactor for each step of control.

H. Automatic Damper Operator:

1. Electric Actuator: 24 volt with remote temperature read and reset capability.

2. Casting with access panel for inspection and maintenance.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install fans level and plumb, in accordance with manufacturer‘s installation instructions. Support units as herein specified, using the vibration control devices as specified in

B. Section 20 30 13, Vibration, Isolation and Seismic Control for Facility Services. Secure fans with galvanized or cadmium-plated hardware. Provide supporting steel, mounting curbs, and anchorage devices as required to properly support the unit.

C. Install suspended units independently from building structure using threaded steel rods and vibration isolators, unless otherwise indicated.

D. Rigidly anchor roof mounted units to roof curbs using galvanized or cadmium plated hardware.

E. Make final connections to ductwork using flexible connectors. Secure flexible duct connectors mechanically to fan and duct to provide airtight joints. Install 1/2-inch mesh bird screen on discharge of weather hood downstream from discharge shutter.

3.02 START-UP SERVICE

A. Provide the services of a factory-authorized service representative to inspect the installation and connections and to provide initial start-up service. Services shall

include a complete operational check and demonstration of the equipment operation to ensure proper operation.

3.03 TRAINING

A. Provide instructions to the District's maintenance personnel on proper operation and maintenance procedures in accordance with Section 01 79 00, Demonstration and Training.

3.04 FIELD QUALITY CONTROL

A. Perform start up tests of air-handling units for proper operation of motor, drive system, and fan wheel. Adjust fan to indicated RPM. Replace fan and motor pulleys as required to achieve design conditions. Measure and record motor electrical values for voltage and amperage. Shut unit down and reconnect automatic temperature control operators as applicable. Perform tests in accordance with the respective manufacturer's instructions and applicable codes and standards.

B. The Engineer will review certificates of compliance and test reports, and witness all tests. Submit certified test results as specified in the Article entitled "Submittals" herein.

C. Refer to Section 23 05 93, Testing, Adjusting, and Balancing for HVAC, for air handling-system testing, adjusting, and balancing requirements and procedures.

END OF SECTION 23 34 00

SECTION 23 34 14

FAN-MOTOR UNITS FOR TUNNEL VENTILATION

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. The work of this Contract Specifications Section includes furnishing, installing, and testing axial-flow fan-motor units and appurtenances as shown on the Contract Drawings.

1.02 RELATED SECTIONS

A. Section 20 60 13, Motors for Facility Services

B. Section 23 05 93, Testing, Adjusting, and Balancing for HVAC

C. Section 23 09 01, Fan Control Panel

D. Section 23 31 14, Ductwork for Tunnel Ventilation

E. Section 23 33 14, Dampers for Tunnel Ventilation

F. Section 23 33 20, Sound Attenuators for Tunnel Ventilation

G. Section 26 05 13, Medium Voltage Cable

H. Section 26 05 24, Low Voltage Wires and Cables

I. Section 26 24 25, Medium Voltage (4.16 kV) Motor Controllers

1.03 MEASUREMENT AND PAYMENT

A. General: Separate measurement or payment will not be made for the work required under this Section. All costs in connection with the Work specified herein will be considered to be included or incidental to the Work of this Contract.

1.04 REFERENCES

A. Where materials or equipment are required to conform to referenced industry standards, the current edition of the most recent revisions as of the date of Notice to Proceed shall apply.

B. Contractor may propose for approval alternate standards to those listed herein, provided that the standards are submitted in the English language, with a point-by-point comparison between the specified and alternate standards included in the submittal. The requirements of proposed alternate standards shall be at least as stringent as the specified standards.

C. Reference Standards

1. Air Moving and Control Association (AMCA):
   a. 204 Balance Quality and Vibration Levels for Fans.
   b. 210 Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.
2. American Bearings Manufacturers Association (AFBMA).
   a. 9 Load Ratings and Fatigue Life for Ball Bearings.
   b. 11 Load Ratings and Fatigue Life for Roller Bearings.
3. American National Standards Institute (ANSI):
   a. C1 General Requirements of a Quality Program.
   b. S12.36 Survey Methods for Determination of Sound Power Levels of Noise Sources.
4. American Society of Mechanical Engineers (ASME):
   a. B18.21.1 Lock Washers.
5. American Society for Non-Destructive Testing (ASNT)
6. ASTM International (ASTM):
   a. A 36 Carbon Structural Steel.
   b. A 193 Alloy-Steel and Stainless Steel Bolting Materials for High Temperature Service.
   c. A 194 Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service.
   d. A 388 Recommended Practice for Ultrasonic Examination of Heavy Steel Forgings.
   e. B 117 Standard Practice for Operating Salt Spray (Fog) Apparatus.
   f. B 247 Aluminum Alloy Die Forgings, Hand Forgings and Rolled Ring Forging.
7. American Welding Society (AWS):
   a. D1.1 Structural Welding Code - Steel.
   b. D1.3 Structural Welding Code - Sheet Steel.
8. Institute of Electrical and Electronic Engineers (IEEE):
   a. 112 Test Procedure for Polyphase Induction Motors and Generators.

9. International Organization for Standardization (ISO):

    a. 1940 Mechanical Vibration - Balance Quality Requirements for Rotors in a Constant (Rigid) State - Part 1: Specification and Verification of Balance Tolerances.

10. National Electrical Manufacturer's Association (NEMA):

    a. MG-1 Motors and Generators.

11. National Fire Protection Association (NFPA):

    a. 70 National Electrical Code (NEC).

    b. 130 Standard for Fixed Guideway Transit and Passenger Rail Systems.

12. Steel Structures Painting Council (SSPC):

    a. PA-1 No. 1 Shop, Field and Maintenance Painting.

    b. PA-2 Method for Measurement of Dry Paint Thickness with Magnetic Gauges.

    c. SP-3 Power Tool Cleaning.

    d. SP-10 Near White Blast Cleaning.

1.05 COORDINATION

A. The fan-motor unit manufacturer shall coordinate with the sound attenuator manufacturer to confirm that combined fan-attenuator noise (fan sound power level minus attenuator dynamic insertion loss) does not exceed the combined fan-attenuator noise shown in the Equipment Schedule in the Contract Drawings. The Contractor shall ensure that the fan-motor manufacturer and the sound attenuator manufacturer jointly provide written certification that the fan-motor units and attenuators have been coordinated so that combined fan-attenuator noise does not exceed the combined fan/attenuator noise shown the Equipment Schedule in the Contract Drawings.

B. Contractor shall ensure that the fan-motor manufacturer and the power and controls system provider for the emergency ventilation system have been coordinated. The Contractor shall ensure that the Fan, Power and Controls suppliers jointly provide written certification that the respective equipment has been coordinated so that the factory and field test performance of the fans can be repeated with the field installed power, controls and motor starting equipment.

C. Contractor shall ensure that the fan-motor unit manufacturer confirms with the sensor and probe manufacturer(s) the suitability of the sensor / probe mounting to the motor housing and that any shaft milling or other modifications for the mounting and operation of the sensors / probes are compatible. Contractor shall ensure that the motor manufacturer provides probe / sensor enclosure design and mounting means.

1.06 SUBMITTALS

A. Provide submittals in accordance with Contract Specifications Section 01 33 00, Submittal Procedures, Contract Specifications Section 01 33 23, Shop Drawings, Product Data, and Samples, Contract Specifications Section 01 42 19, Reference Standards, and the requirements of Article 1.06 herein. In case of any conflict, the more stringent requirements will take precedence. Drawings and Graphs shall be readable and shall be submitted on a minimum of 11″ x 17″ size paper.

B. Prior to award of contract to fan-motor manufacturer, Contractor shall submit a complete list of projects on which similar fans for rail or transit station projects in the United States have been applied. List shall include:

1. Name of owner or user (include the Owner's installations, if any).
2. Contract number(s).
3. Original installation date(s).
4. Current condition of equipment.
5. A list of all known failures for the past 10 years, including their apparent causes, corrective work effected (including design changes), and a description of equipment service and operating conditions.

C. Within 90 Days after Notice to Proceed, Contractor shall submit evidence of his qualifications, including, but not limited to the following data:

1. Theoretical fan-motor composite performance curves for equipment proposed to be furnished under this Contract.
    a. Fan-motor unit performance curves from shut-off to free delivery shall have the following data plotted as ordinates versus airflow rate, in cubic feet per minute, as abscissa:
        1) Fan total pressure, inches of water.
        2) Fan static pressure, inches of water.
        3) Fan velocity pressure, inches of water.
        4) Total efficiency, percent.
        5) Horsepower input to fan impeller.
        6) Kilowatt input to the motor.
    b. Separate curves shall be furnished for forward and reverse direction. Each curve shall be identified.
    c. System resistance curves shall be plotted for each rotational direction with the point of operation indicated.

d. Theoretical performance curves for each rotational direction shall be plotted for fan-motor units for the installed motor horsepower for the following blade pitch angles:

   1) Maximum blade pitch angle for installed motor horsepower.

   2) Minimum blade pitch angle.

   3) Design blade pitch angle.

   4) A minimum of four intermediate pitch angles between maximum and minimum blade pitch angle other than design pitch angle.

e. Acceleration time for each rotational direction from standstill to operating revolutions per minute (rpm). Plot operating rpm as abscissa and acceleration time as ordinate.

f. The fan load torque and motor torque curves from standstill to operating speed. Plot percent revolutions per minute as abscissa and percent full-load torque as ordinate.

g. All performance curves shall be plotted on minimum 11″ x 17″ sheets to such scales and with a grid that will make it possible to read the data accurately.

h. The following information shall be indicated on each theoretical and actual performance curve:

   1) Contract title.

   2) Contractor’s name.

   3) Name and address of fan manufacturer.

   4) Fan designation number.

   5) Fan housing inside diameter in inches.

   6) Fan outlet area in square feet.

   7) Fan rotor hub diameter in inches.

   8) Fan speed in revolutions per minute.

   9) Number of fan blades.

   10) Design blade pitch angle.

   11) Rotational moment of inertia of fan rotor assembly in pounds-foot squared.

   12) Maximum acceleration time required to start fan-motor unit from rest and accelerate it to operating speed against the design duty resistance, in seconds, at rated voltage.

   13) Air density in pounds per cubic foot.

   14) Direction of airflow (forward or reverse).

   15) The following data at the operating point:

      a) Fan static pressure in inches of water.

      b) Fan total pressure in inches of water.

c) Fan outlet velocity pressure in inches of water.
d) Fan outlet velocity in feet per minute.
e) Fan total efficiency in percent.
f) Motor efficiency in percent at operating point.
g) Fan-motor unit total efficiency in percent.
h) Horsepower input to fan impeller.
i) Kilowatt input to motor.

2. Theoretical fan motor performance curves covering the entire range of load conditions from no load to not less than 115 percent of full load at 110 percent, 100 percent, 90 percent, and 85 percent of motor rated voltages.

   a. Composite curve for each motor horsepower size plotted with abscissa as horsepower output and ordinates as:

      1) Current in amperes.
      2) Speed in rpm.
      3) Efficiency in percent.
      4) Power factor in percent.
      5) Torque in foot-pounds.

   b. Composite curve for each motor horsepower size plotted with abscissa as speed in revolutions per minute and ordinates as:

      1) Motor current in amperes.
      2) Motor torque in foot-pounds.
      3) Fan torque in foot-pounds.
      4) Motor acceleration from standstill to operating speed in seconds.

   c. Motor Winding and Bearing Temperature Test: Time in minutes as abscissa versus temperature rise in degrees Celsius as ordinates when operated at full voltage and speed.

   d. Insulation Resistance-Temperature Test: Test result values shall be plotted on semi-logarithmic graphs, the insulation resistance values as logarithmic ordinates and the temperature values degrees Celsius or degrees Fahrenheit as uniform abscissa.

   e. In addition, for comparison purposes, a curve indicating the safe operating value of insulation resistance shall be plotted on the same sheet with the insulation resistance temperature test curve.

   f. The following information shall be stated on each motor theoretical and actual performance curve and data sheet:

      1) Contract title.
      2) Contractor’s name and address.
      3) Name and address of motor manufacturer.

4) Fan designation number in which the motor forms a part.
5) Motor type.
6) Motor serial number.
7) NEMA Motor frame size.
8) Motor nameplate horsepower rating.
9) Electrical characteristics (voltage-phase-frequency).
10) Full-load and no-load current in amperes.
11) Locked-rotor current in amperes.
12) Motor torque in pounds-foot including locked rotor torque, pull-up and breakdown torque.
13) Full-load slip.
14) Direction of rotation of motor.
15) Speed in revolutions per minute.
16) Service factor.
17) Rotational moment of inertia of fan rotor (minus motor) in pounds-foot squared.
18) Rotational moment of inertia of motor in pounds-foot squared.
19) Power Factor at 100 percent, 75 percent, and 50 percent load.
20) Motor torque and fan load torque curves indicating net torque margin.
21) Motor efficiency at 100 percent, 75 percent, and 50 percent load.
22) Electrical characteristics of space heater, including voltage and kilowatt input.
23) Motor thermal curve.
24) Verify proper operation of the proximity probes indicating the sense and speed of rotation of the fans by comparing results to items 14 and 15 above.

3. Fan-motor unit theoretical sound power levels in decibels (re: db 10-12 watts) shall be submitted for both directions of airflow for reversible fans at full speed.

4. Name of independent testing company proposed to be used to conduct independent motor factory test.

5. Manufacturer’s quality assurance program in accordance with ANSI C1.

6. List of components proposed to be purchased from other manufacturers, giving name of manufacturer, type and characteristic of each item and applicable data requested under Article 1.06B.1 through Article 1.06B.5 herein above.

D. The Contractor shall submit the following:

1. Certified Shop Drawings including Bill of Materials for fans, motors, fan motor unit bases, installation drawings, installation instructions, dimensioned drawings for anchor bolt locations, and any additional data required to demonstrate compliance with Contract Documents. Shop Drawings shall indicate operating and shipping weights of each component and fully assembled unit.

2. Comprehensive General Arrangement Drawings of fan-motor unit assembly including transition and straight ductwork, flexible connections, sound attenuators, dampers, etc.

3. Drawing of fan blades and hub identifying index marks for setting blade angles.

4. Dimensioned drawings including mounting details of fan and Instrument Panel.

5. Shop Drawings indicating the size and location of each foundation for the fan-motor units in the ventilation structure, reinforcing bar requirements for these foundations and the expected static and dynamic forces and moments generated by the equipment.

6. Submit basis and justification for material selection for fan blades and hub. Submit data on mechanical properties of the fan blades and hub and data on fan blade and hub yield strength at 482 degrees Fahrenheit. Submit calculations to confirm that the blade and hub stress does not exceed 60 percent of the component material yield strength at 482 degrees Fahrenheit with fan operating at maximum speed.

7. Submit calculations taking into account the differential rates of expansion of dissimilar materials, showing the clearance of the blade tips to the fan housing. The Contractor shall ensure that the fan manufacturer submits a table showing the maximum and minimum blade tip clearance at 0, 35, 60, 100, and 482 degrees Fahrenheit.

8. Data sheet on motor bearing lubricant, Manufacturer’s Safety Data Sheet (MSDS), frequency of lubrication and amount of lubricant to be supplied during lubrication.

9. Complete factory and field test procedures.

10. List of technical support items specified and list of any additional support items required.

11. Motor terminal and auxiliary box drawings including electrical wiring diagrams of motor and monitoring device connections.

12. Complete fan and motor nameplate drawings.

E. Within 21 Days after successful completion of tests specified herein and of any additional tests conducted at Contractor's own option, Contractor shall submit the following:

1. Certified test results for all fan and motor factory tests conducted. All test data shall be bound in one report. The test report shall be indexed and cross-referenced in an easily understood manner.

2. All records and results of non-destructive examinations made at completion of each examination.

3. Field test results.

4. Radiographic inspection films.

5. Furnish Shop Drawing of each fan impeller indicating the fan blade number and weight of each fan blade and blade and hub x-ray numbers with the factory test report.

F. Operation and Maintenance Manuals

1. At least 30 Days before shipment of the first fan-motor unit, Contractor shall submit for approval three copies of the Operation and Maintenance (O&M) Manual, which shall provide technical support for fan-motor unit maintenance. After approval of the preliminary submittal and having made all necessary corrections and amendments required, Contractor shall provide six (6) additional copies of the approved dated O&M Manual. One master camera-ready set shall be included as one of the six (6) copies to permit additional copies to be made. The master camera-ready set shall be clearly marked as such on the outside. An electronic copy of the O&M Manual text, drawing and catalog cut files shall also be provided. The O&M Manual shall provide a clear explanation of the theory, operation, and maintenance of the equipment accompanied by photos and schematic, wiring, and mechanical assembly diagrams, as required. The O&M Manual shall be indexed and cross-referenced in an easily understood manner. The O&M Manual shall be loose-leaf bound and shall include, but not necessarily be limited to, the following information:

   a. Troubleshooting and fault isolation procedures for on-site level repair.

   b. Fan and motor removal and replacement procedures, including instructions on aligning motor and fan impeller in fan housing.

   c. Fan and motor disassembly and re-assembly instructions.

   d. Procedure for static and dynamic rebalancing of fan impeller in the field.

   e. A list of the components, which are replaceable at the three possible levels of maintenance: on-site, shops, and the Fan Manufacturer's facility.

   f. A test procedure to verify the adequacy of repair work for fan and motor.

   g. A preventive maintenance schedule and instructions detailing lubrication of moving parts and monitoring of sound and vibration levels.

h. Procedures for separately removing and replacing motor, fan rotor, and blades as well as procedures for removing a complete fan-motor unit without disassembly.

i. A list of special tools provided by the fan manufacturer.

j. Metal templates for blade angle setting for each fan.

k. A list of tools and test equipment required to perform all maintenance tasks.

l. Approved Shop Drawings.

m. Fan and motor factory test reports.

n. Field testing procedures and list of required equipment.

o. Methodology for determining whether a fan can continue to be operated after exposure to a fire event.

p. The latest service bulletins with dates which describe service procedures.

q. Contractor shall notify the District Representative of any revision to service bulletins that are included in the O&M Manual described herein for a period of five years from the date of facility opening for revenue service.

G. Technical Support Items: At least 30 Days before shipment, Contractor shall submit the following:

1. Ten sets of special tools shall be provided in total. Special tools shall be those tools, which are required to specifically service or repair the fan unit which is being supplied and that are not normally carried in a general mechanic's toolbox. Special tools would include torque wrenches, large wrenches or sockets (for bolts 3/4-inch or larger), templates for blade adjustment, calibration equipment for sensors / probes, etc.

2. Tabulation of technical support items necessary to maintain the fans procured under this Contract. This table will become a working document to be used by the District in the procurement of support items, and shall be updated as changes occur. The technical support items shall be grouped by equipment and components. This list for each item shall give complete ordering and procurement information for that item, including quantity required to maintain inventory for 500 hours operation. Each item listed shall contain at least the following information:

   a. Item name.

   b. Description rating.

   c. Estimated operating life.

   d. Current price.

   e. Manufacturer's name.

   f. Part name.

   g. Drawing reference number.

3. Items that are common to more than one fan shall be cross-referenced. A column, immediately after the columns indicating recommended spare quantities, shall indicate expected delivery time in excess of 60 Days.

4. The Contractor shall submit a recommended spare parts list in accordance with Contract Specifications Section 01 78 44, Spare Parts and Maintenance Manuals.

H. Prior to Substantial Completion the Contractor shall submit training materials in accordance with Contract Specifications Section 01 79 00, Demonstration and Training.

I. Record Drawings: Submit Record Drawings in accordance with Contract Specifications Section 01 78 39, Contract Record Documents.

J. Prior to Substantial Completion the Contractor shall submit information on the warranty (see Supplementary Conditions Article SC4.7, Guaranty of Work).

K. Templates for Setting of Blade Angles: Contractor shall provide metal templates or other approved devices to facilitate settings of blade angles in the field. One template shall be provided attached to each fan unit in a location that is subject to the District Representative approval. One template shall be provided with each O&M Manual.

1.07 QUALITY CONTROL

A. Source Quality Control

1. Fans shall be the product of a single manufacturer whose name shall appear on the theoretical fan-motor unit performance curves and other data submitted.

2. All fan motors shall be the product of a single manufacturer whose name shall appear on the theoretical motor performance curves and other data submitted.

B. Manufacturer’s Qualifications: Contractor shall ensure that the fan manufacturer submits documents to show continuous and current experience in the design, assembly, and testing of axial-flow tunnel and Station ventilation fans and experience in the design and fabrication of units capable of operating in an airstream at a temperature of not less than 482 degrees Fahrenheit for not less than one hour and an airstream of not less than 392 degrees Fahrenheit for not less than two hours.

C. Welding: All components in this Contract requiring welding shall be welded as follows:

1. Code Requirement: Welding shall conform to the requirements of AWS D1.1 and AWS D1.3.

2. Welder Qualification: Welders welding on the work of this Contract shall be certified in accordance with AWS D1.1. Copies of welder certifications shall be provided.

3. Process: The welding process employed on the Work of this Contract shall be the shielded metal arc process, in accordance with AWS D1.1.

1.08 STORAGE AND PROTECTION

A. Storage: Store all materials and equipment in dry, ventilated, weather tight enclosures.

B. Protecting Machined Surfaces: Apply a rust preventive on machined surfaces such as flanges and shafts. Use material of a type that is easily removable with solvent during equipment installation.

C. Protecting Openings: Close pipe connections, ends, and other openings with easily removable plugs, stoppers, or flange covers.

D. Motor space heaters shall be energized within 24 hours after the unit is delivered to the storage facility or Contract Construction Jobsite. The motor heaters shall also be energized while in storage awaiting the fabrication of the fans, in accordance with the manufacturer's instructions.

1.09 CONTRACT/JOBSITE CONDITIONS

A. Design Temperature Conditions. Fan-motor units and all parts thereof shall be capable of withstanding the effect of all stresses and loads under starting, operating, and reversing conditions specified. Fans and all components shall be capable of operating for not less than one (1) hour in an ambient temperature of not less than 482 degrees Fahrenheit and for not less than an additional two hours at not less than 392 degrees Fahrenheit.

B. Fans, motors, and components shall be capable of withstanding sudden temperature changes because of fire between the extremes of 35 and 482 degrees Fahrenheit or vice versa in a time frame of 20 seconds.

C. Fan-motor units shall be designed for the orientation, horizontal or vertical, shown on the Contract Drawings, and they shall be designed and built to serve an underground environment and to function under conditions of high humidity and high temperature and the inlet and outlet conditions as indicated.

D. Power Supply. Power will be supplied at the rated characteristics as shown on the plans.

1.10 SPARE PARTS

A. Provide the District Representative with one spare impeller hub and one complete set of spare fan blades for each size hub and blade provided. Store spare hub and blades in secure storage containers with permanent labels identifying number, type, manufacturer and the District's Construction Contract Number.

B. Provide the District Representative with one spare set of sensors and probes identical to the sensors and probes supplied for each motor horsepower size fan-motor unit. Store spare sensors and probes in secure storage containers with permanent labels identifying number, type, manufacturer and the District's Construction Contract Number.

C. Provide the District Representative with one spare fan motor identical to the motors supplied for each motor horsepower size fan-motor unit. Store spare motor in secure storage containers with permanent labels identifying number, type, manufacturer and the District's Construction Contract Number.

PART 2 – PRODUCTS

2.01 FAN-MOTOR UNITS

A. Description

1. Fan-motor units shall conform to all the regulatory requirements of the California Building Code, NFPA 70 and NFPA 130 where applicable.

2. Fans shall be axial-flow type with reversible operation. Fan-motor units shall be required to operate in the forward or reverse direction of airflow, with a capability of starting, stopping, or reversing the direction of flow at any time.

3. Fan-motor units shall be direct-driven by internally-mounted electric motors, with provision for manual adjustment of the individual blade angle. Fan-motor units and their supports shall be designed and constructed for the arrangement shown on the Contract Drawings.

4. Motors shall conform to the requirements of Article 2.03 contained herein. Motors shall not be provided with self-contained thermal protective devices.

B. Fan-Motor Unit Design Requirements

1. Fan-motor unit performance shall be rated for the airflow and total pressure specified on the Drawings at the air density shown on the Contract Drawings.

2. Fan-motor unit performance curves for either direction shall rise continuously with decreasing flow between free delivery and 60 percent of free air delivery or to maximum horsepower rating. Fans shall be capable of operating continuously at specified design points for forward and reverse flow. For the purpose of this Contract, forward flow shall be designated as exhaust mode (airflow from trainway to atmosphere) and reverse flow shall be designated as supply mode (airflow from atmosphere to trainway).

3. Fan-motor units shall have a total efficiency of not less than 60 percent and shall be in compliance with Section 20 60 13, Motors for Facility Services. Motors shall have a minimum overall efficiency of 90 percent at the rated load as indicated in Article 2.03 herein.

4. Fan-motor units shall be capable of accelerating from a standstill to rated rotational speed at the design duty air quantity and pressure, in either direction, in not more than 15 seconds and without failure of any part of the unit, when started across-the-line with rated voltage at the motor terminals and a voltage dip of not more than 15 percent of the rated voltage. Fan-motor units shall be capable of reversing to full speed from either direction of airflow and rotation during an emergency within 15 seconds when started across-the-line with rated voltage at the motor terminals and a voltage dip of not more than 15 percent of the rated voltage, after a 10-second delay between power interruption and the energizing of the motor for the reversed rotation, without failure of any part of the unit.

5. Brake horsepower input to fan impeller shall not exceed the nameplate horsepower rating of the fan motor when operating in either direction of airflow.

6. Pressure variations of plus or minus 1.50 inches water gauge induced by external causes shall not result in movement of the fan operating point along the total pressure fan operating curve into the region of unstable operation. The definition of the region of unstable operation shall be any point that is not on the negatively sloping portion of the pressure curve. This requirement does not affect the horsepower requirement for the design operating point.

7. Any indication of a flat or unstable region in the fan curve shall be thoroughly evaluated to confirm the location of the unstable region in relationship to the operating point.

8. Fans shall not operate in stalling range of fan performance curve (region of unstable operation) during parallel operation (forward or reverse direction).

9. Fans shall have a stable operating characteristic in both directions of free flow over the range from 50 percent nominal flow to free delivery.

10. No fan blade or fan wheel impeller assembly shall have a natural frequency within plus or minus 10 percent of two, three and four times the operating frequency nor at the blade pass frequency defined as number of blades times natural operating frequency.

2.02 FAN FABRICATION

A. Impeller Hub and Blades

1. Impeller hub shall be fabricated of aluminum alloy castings, aluminum alloy forgings, steel or stainless steel, suitable for the specified performance, environment and temperature specified. Aluminum forgings shall be in conformance with the requirements of ASTM B 247.

2. Blades shall be forged aluminum. Blades shall be matched in pairs and be matched in fan sets. The matched pairs shall weigh within 0.2 percent of each other. Blades in the fan set shall be selected to weigh within one percent of all other blades in the fan set. Blades shall be manufactured of a homogeneous material and shall have no cast-in or embedded materials of any kind. Individual blades shall be secured to the hub by not less than four bolts per blade, or shall be clamped securely between the two halves of a split hub or between suitably designed and manufactured clamp plates.

3. Fan rotating components shall be designed such that no measured or calculated stress level shall exceed 60 percent of the components materials yield strength at design temperature of 482 degrees Fahrenheit.

4. The fan motor and hub assembly shall be balanced in the shop to not exceed a vibration velocity of 0.0196 IPS - Peak. Fan units shall comply with a maximum peak vibration velocity of 0.0392 IPS when installed in the actual system configuration on the fan support pad or foundation.

5. Blade bolts, hub bolts or clamp plate bolts shall be readily accessible. The pitch of the blades shall be manually adjustable without removing impeller from fan unit. Pitch is defined as the angle formed by the chord line of a blade root cross-section and a line parallel to the direction of rotation. The ratio of the hub diameter to the fan housing diameter shall not be less than 0.35. The hub shall have index marks embossed or engraved to show the design operating blade setting and the blade settings for a minimum of five additional blade angle increments with not less than two on each side of the design setting. Engraving shall be done at a low stress location on the hub.

6. Blade tracking shall not exceed plus or minus 1/8 inch.

B. Fan Housings

1. Fan housings, including motor mounts and motor supports shall be fabricated of hot-rolled steel not less than 1/4-inch thick. Clearance between housing inner diameter and blade tips shall be sufficient to allow for thermal growth difference between fan blades and fan housing at a temperature of 482 degrees Fahrenheit. Fan housing shall be provided with split joints except for impeller section. Housing sections shall be bolted, and gasketed to facilitate disassembly and removal of motor, rotor, shaft and bearings without removal of entire fan-motor unit or any part of adjacent ductwork.

2. Welds located in the airstream shall be ground smooth. Flanged rings shall be continuously welded to the outer periphery at each end of the housings, or flanges may be rolled as part of the housing. Flanges shall be not less than three inches wide and not less than fan housing thickness. Flanges shall have punched or drilled holes equally spaced not more than eight inches on centers to permit adjacent duct elements to be bolted to the housings.

3. Provide remote lubrication fittings for lubrication of motor bearings from easily accessible location, as approved by the District Representative. All maintenance fittings, connections, access hatches, etc. shall be located on the same side of the fan housing.

C. The rotor assembly shall be fastened to the motor shaft by means of an approved keyed positive locking device that is fully effective for both directions of rotation, for all blade angle settings, and for all conditions of operation specified. The rotor assembly shaft shall be an extension of the drive motor shaft and shall be restrained longitudinally by a locking fastener and shoulder connection. This connection shall not be a custom design.

D. Motor mounts and motor supports shall be designed to support the entire weight of the impeller and the motor, and to maintain the alignment of the fan-motor unit assembly in the specified mounting orientation and to maintain vibration levels within the specified limits. Motor supports shall be sufficient in number to provide the required strength and rigidity and shall be continuously welded to the motor mount and to the fan housing. Fan motor and fan rotor assembly shall be totally enclosed within the fan housing and not protrude at either end of the fan housing.

E. Nosepiece cover plates, access doors, and aerodynamic separation plates, where provided, shall be secured by means of positive fastening devices which are fully effective for both directions of impeller rotation, for all blade settings, and for all conditions of operation specified herein.

F. Fan-motor unit assembly supports shall be of carbon steel not less than 3/8-inch thick conforming to the requirements of ASTM A 36. Supports shall include fan-motor unit structural steel base with vertical supports for horizontal fan orientation (horizontal supports for vertical fan orientation) extending from the base to the fan housing centerline flange and with horizontal thrust plates for horizontal fan orientation (vertical thrust plates for vertical fan orientation) extending over the full length of the fan housing. Vertical supports and thrust plates shall be welded continuously to the surfaces with which they come into contact.

G. Terminal Boxes. The motor leads for power, motor heater, monitoring and control shall be suitable for operation at Design Temperature Conditions Article 1.09A herein, wired to separate power and auxiliary terminal boxes conforming to NEMA 12 requirements mounted externally to the fan housing. The Power Junction Box and Auxiliary Box shall be rigidly secured to the fan housing or separate channel frame in a manner which will prevent vibration and air leakage and shall be capable of withstanding Design Temperature Conditions without causing fan failure. Terminal boxes shall be mounted on the fan casing in the location shown on the Contract Drawings and oriented to accommodate the conduit entry shown. Motor terminals and connectors shall be as described in Division 26. Control cables shall conform to the requirements of NFPA 130 and as described in Contract Specifications Section 26 05 24, Low Voltage Wires and Cables. Sufficient cable slack shall be provided to permit testing of cables without disconnecting any connections. Vibration detector cables shall have sufficient length to reach monitors installed in the Fan Instrument Panel. Provide amplifiers for monitoring sensors as recommended by the manufacturer.

1. Power Junction Box. Motor terminal box for power leads shall be at least one size larger than required by NEMA MG-1.

2. Auxiliary Box shall have screw-type pressure terminal strips for terminating control wires, exterior mounting lugs, full cover gasket, hinged door, minimum inside dimension of 24 inches high by 24 inches wide by 12 inches in depth. Auxiliary boxes shall be sized to provide device and wiring clearances conforming to NFPA 70.

3. In order to meet the requirements of NFPA 130 that covers the tunnel area, all cables running from the motors junction box and through ducts/plenum up to the Junction Box placed outside the tunnel section shall conform to the requirements of NFPA 130 and as described in Contract Specifications Section 26 05 24, Low Voltage Wires and Cables.

H. Fan Instrument Panel shall be mounted remotely from the fan housing and shall have screw-type pressure terminal strips for terminating control wires, exterior mounting lugs, full-cover gasket, and hinged door, sized as required, for vibration monitor, RTD relays and associated wiring. Panel shall be sized to provide device and wiring clearances conforming to NFPA 70. Panel shall be NEMA 4X S.S. Enclosure 16 inches x16 inches x 6 inches.

I. Grease supply and relief lines shall be brought from each motor bearing to accessible lubrication fittings, external to the fan housing, accessible from the floor level of the fan room as approved by the District Representative. The lines shall not be less than 1/4 inch (nominal) in diameter and shall be fabricated of stainless steel or other corrosion resistant alloy, seamless metallic tubing. The tubing shall not be crushed or scored during installation and the lines shall have neither kinks nor sharp bends. Lines penetrating the housing shall be rigidly secured to the housings to prevent vibration of the lines and be provided with grommets. Grease supply lines shall terminate in straight lubrication fittings. Grease fittings shall only allow the proper amount of grease to each bearing. The bearing lubricant shall be capable of providing the lubrication properties specified by the bearing manufacturer under Design Temperature Conditions Article 1.09A herein and also at a temperature of 35 degrees Fahrenheit.

J. All electrical connections, instrumentation connections, grease fittings, access hatches and etc. shall be located on the same side of the fan. Maintenance personnel shall not have to access both sides of the fan to perform maintenance and standard repair operations.

K. Contractor shall provide a 1/4-inch thick silicone gasket between all adjacent companion flanges; width of gasket shall be same as flange width. Gaskets shall be capable of withstanding Design Temperature Conditions Article 1.09A herein without degradation of sealing ability and without emitting toxic or noxious fumes.

L. Sufficient lifting eyes shall be provided on each fan assembly to facilitate on-site installation and removal of the fans.

2.03 MOTOR COMPONENTS AND CONSTRUCTION

A. General Requirements

1. Motors shall be of the totally enclosed, air-over, cast iron or steel round frame, induction type, continuous duty, variable torque, and shall be flange, pad, or foot-mounted. Motor nameplate rating shall be as indicated on the plans. Motor service factor shall be 1.15. Motors shall be suitable for operation with Power Supply. During continuous operation, motors shall be insensitive to line voltage variation of 10 percent above and below the rated motor voltage and to normal frequency variations described in NEMA MG-1. The motor shall be designed for stopping a free-wheeling impeller and accelerating that fan impeller from standstill to operating speed without exceeding the rated temperature rise.

2. Motors shall be rated in accordance with NEMA MG-1 for the locked-rotor input (kilovolt amperes per horsepower) required to meet the specified acceleration performance. Motor and shaft shall be designed for full plug reversal. Motors shall have a minimum of Type H insulation and shall be rated for Class B temperature rise when tested at the service factor load as a minimum requirement.

3. Nameplate horsepower shall be actual continuous brake horsepower developed without any consideration of the “air-over” factor.

4. The motors shall be designed for continuous operation for the time durations and temperatures specified in Article 1.09A, Design Temperature Conditions herein.

5. All fan motors shall be new. Components from motors subjected to high temperature testing shall not be used in the fabrication of the new motors supplied for this Contract.

6. Motors shall be equipped with factory-installed resistance space heaters within the motor enclosure to prevent condensation of moisture in the motor windings. Heaters shall be 120 volts, single phase. The heaters shall be provided with leads terminated in the Power Junction Box external to the fan housing.

7. Motor horsepower shall be as indicated on the nameplate. Horsepower input required by the fans shall not exceed the nameplate horsepower of the motors for pressure variations of plus or minus 1.50 inches water gauge along the design fan operating curve in either direction of airflow. Motors shall have a minimum overall efficiency of 90.0 percent at the rated load. The locked-rotor torque shall not be less than 145 percent of the motor full-load torque. Motor pull-up and breakdown torque percentages of full-load torque shall be in accordance with NEMA MG-1 for nameplate high speed horsepower. The locked-rotor current shall not exceed 6.5 times the full-load current with rated Power Supply at the motor terminals.

8. Each motor bearing shall be provided with a vibration detector for measuring bearing vibration. The detector sensor shall be permanently encapsulated, coated electronics using microprocessor digital circuitry, with transducer wired to the vibration monitoring device located in the Fan Instrument Panel external to the fan housing. The accuracy of the detector shall be a maximum of 20 percent of detector level within temperature range.

9. Vibration monitors shall provide high vibration alarm and trip contacts from each detector to the motor protection relay in the fan starter. The monitors shall incorporate a local digital display of vibration levels, and alarm and trip levels, and shall be equipped with alarm contacts to provide local audible and visual alarms of high vibration.

10. Motors shall be provided with six (two per phase) resistance temperature detectors (RTD's) wired to the Fan Instrument Panel. Analog signals from the RTD's shall be extended from the Fan Instrument Panel to the motor protection relay in the fan starter using shielded cables.

11. Each motor bearing shall be provided with one resistance temperature detector (RTD) wired to the Fan Instrument Panel. Analog signals from the RTD's shall be extended from the Fan Instrument Panel to the motor protection relay in the fan starter using shielded cables.

12. Minimum power factor of motors shall be 85 percent at the rated load.

13. The starting and accelerating torque on motor winding shall be sufficient to permit the motor rotor and fan impeller to attain full speed without tripping the motor controller overload relays, which shall be set at a current corresponding to 140 percent of the motor full-load current.

B. Motor Materials and Components

1. Motor shafts shall be steel, designed and constructed to support and drive the fan impeller under all specified operating conditions.

2. Each motor shall have at least two ball or roller type grease-lubricated, electric motor grade, noise-tested bearings selected for the specified operating conditions of the fan motor unit. Determination of axial thrust load on motor bearings shall include addition of the weight of rotating assembly for vertically-installed fan-motor units. The bearings shall be based on AFBMA 9 or 11 and shall have a minimum L 10 life rating of 40,000 hours at maximum motor horsepower capacity and maximum speed based on the bearing load imposed by driven equipment.

3. Lifting lugs shall be provided on the exterior of motors.

C. Control wiring

1. All control wiring of motor and fan has to conform to the requirements of NFPA 130 and as described in Contract Specifications Section 26 05 24, Low Voltage Wires and Cables.

2.04 DEVICES

A. Proximity Probes:

1. A set of proximity probes shall be provided and installed on the motor / shaft of each fan in order to provide monitoring of direction and speed of rotation of the fan motor. Contractor shall coordinate with fan-motor manufacturer to confirm suitability of motor / shaft milling for the mounting and operation of the probes with the proximity probe manufacturer. Contractor shall ensure that the motor manufacturer provides probe enclosure design and mounting means to the motor shaft. Two transducer probes are required for each motor shaft and are to be installed in accordance with manufacturer’s installation instructions and as shown on the associated Contract Drawings. Contractor shall also provide and install all associated controller, wiring, and accessories necessary for the operation of the proximity probes. The Controller shall be installed in the Fan Control Panel (FCP). The proximity probe controller shall provide speed and direction of rotation information including alarm and trip contacts back to the fan controller. The monitors shall incorporate a local digital display of speed and direction of rotation, and alarm and trip levels that shall be transmitted back to OCC.

2. Electrical current and voltage phase rotation detectors shall be provided for each motor of each fan in order to provide monitoring of direction and speed of rotation of the fan motor. Contractor shall coordinate with fan-motor manufacturer to confirm suitability of these detectors and for the mounting and operation of these detectors with the detector manufacturer. Contractor shall also provide and install all associated controller, wiring, and accessories necessary for the operation of these current and voltage phase detectors. The Controller shall be installed in the Fan Control Panel (FCP). The current and voltage phase rotation detector controller(s) shall provide high current alarm and trip levels that shall be transmitted back to OCC.

3. Diaphram type pressure sensors, two each shall be provided in a NEMA 4 enclosure. These sensors shall be connected to 1/4 copper tubing probes mounted at each end of the fan. These copper tube probes shall be arranged to sense the positive and negative pressure produced on each side of the fan unit. The pressure sensors shall be connected to an associated controller, wiring, and required accessories. Contractor shall also coordinate the fan-motor manufacturer with the sensor manufacturer to provide the necessary mounting and operation of these sensors and controllers. The Controller shall be installed in the Fan Control Panel (FCP) and shall provide alarm and trip contacts from each sensor controller that shall be transmitted back to OCC.

4. All of the individual device controllers listed above shall be connected to OCC and shall provide both individual speed and rotation indications but also provide a trouble alarm if any of the controllers are in conflict with the other controllers.

2.05 SHOP FINISHES

A. After fabrication and before assembly, all inside and outside surfaces of all fan housings, fan housing extensions, supports, fan-motor unit bases and exterior of fan motors shall be prepared in conformity to the requirements of SSPC SP-10 and shall be given a rust inhibiting coating, which may consist of an approved plastic coating, or bonderizing, or phosphatizing, followed by the application of a suitable rust inhibiting zinc-rich primer and finish epoxy and urethane paint that is resistant to abrasion and to exposure to elevated temperatures. Surface finish shall be capable of withstanding:

1. Design Temperature Conditions specified in Article 1.09A herein without degradation of its protective quality, and without emitting toxic or noxious fumes.

2. Two hundred hours in salt spray fog test, in accordance with ASTM B117. Immediately upon removal of the panel from the test, the film shall not show any visible blistering or rust spots, and there shall not be over 1/8 inch of rust creepage on either side of the scratch mark.

B. Provide colors as directed by the District Representative.

C. Applied and cured paint shall be tested to ensure that the specified dry film thicknesses are achieved. The dry film thickness of each coat shall be measured in place with a calibrated magnetic film thickness gauge. Measurement of dry film thickness shall be in accordance with the requirements of SSPC PA-2.

D. Paint manufacturer's printed paint application instructions shall be submitted. Submit four samples of the specified primer paint and top coat paint coats applied together on light gauge carbon steel sheet. The paint coats shall be applied shingle fashion to expose each representative coat. The samples shall be 12 inches square and shall be marked with manufacturer's type and color designation.

E. Machined surfaces not requiring painting shall be provided with a coating of anti-corrosion compound before leaving the place of manufacture.

F. Surface finishes damaged during transport or assembly shall be restored to their original condition and color by the installing contractor.

G. Application

1. The minimum height of profile after completion of blast cleaning shall be 1.5 mils.

2. Surfaces of motors to receive primer paint material shall be prepared in accordance with SSPC SP-3. Surfaces specified to receive paint shall receive one coat of primer paint material, two intermediate coats, and one top coat paint material.

3. The top coats shall be tinted to differentiate between coats.

4. The minimum dry film thickness of the primer coat shall be 3 mils Dry Film Thickness (DFT). Provide the manufacturer's recommended zinc-rich epoxy primer that is compatible with the substrate and finish materials indicated.

    a. Ameron "Amercoat 68HS, 3 to 5 mils DFT; or

    b. Carboline "858 Zinc-Rich Epoxy Primer", 3 to 5 mils DFT; or

    c. Sherwin-Williams Zinc-Clad IV, or equal.

5. The minimum dry film thickness of each intermediate and top coat shall be 3 mils DFT.

    a. Two intermediate coats shall be high-build epoxy such as Ameron "Amerlock 400", Sherwin-Williams "Epoxy Mastic Aluminum II", Carboline "893 Epoxy", or equal.

    b. Final top coat shall be urethane such as Ameron "Amerishield", Sherwin-Williams "Hi-Solids Polyurethane", Carboline "133 HB Aliphatic Polyurethane", or equal, capable of resistance to weather, abrasion, and salt solutions, having a wide selection of available colors.

6. Primer paint material and top coat paint material shall be applied in accordance with the requirements of the paint material manufacturer's printed paint application instructions and in accordance with the applicable non-conflicting requirements of SSPC PA-1.

2.06 HARDWARE

A. Fasteners

1. In accessible areas, fasteners shall be hexagonal nuts, provided with heavy-duty lock washers.

2. In inaccessible areas, fasteners shall be hexagonal head tap bolts, provided with heavy-duty lock washers.

3. Bolts shall not be less than one-half inch in diameter unless otherwise indicated.

4. Bolts and tap bolts shall be stainless steel and shall conform to the requirements of ASTM A 193, Grade B8M or B8MA, equivalent to AISI Type 316, with suitable lock washers.

5. Nuts shall be stainless steel and shall conform to the requirements of ASTM A 194, Grade 2H, equivalent to AISI Type 316.

6. Lock washers shall be stainless steel, equivalent to AISI Type 316, and shall conform to the requirements of ASME B18.21.1.

B. Anchor Bolts:

1. Anchor bolts shall be stainless steel and shall conform to the requirements of ASTM A 193, Grade B8M or Grade B8MA, equivalent to AISI Type 316, with suitable lock washers.

2. Anchor bolt nuts shall be stainless steel and shall conform to the requirements of ASTM A 194, Grade 2H, equivalent to AISI Type 316.

2.07 NAMEPLATES

A. Each fan shall be provided with a stainless steel nameplate permanently stamped with the name and address of the manufacturer, Contractor's identification number, fan type, the Contract Drawing's designated fan number, shop order, serial number of fan, year of manufacture, maximum safe operating speed of fan in revolutions per minute, fan impeller diameter, maximum design operating speed and corresponding volume of air delivered and the fan total pressures at density specified. The nameplate shall be securely screwed or riveted to the exterior of fan housing in a conspicuous position.

B. Each fan shall be provided with a stainless steel enamel plate which shall bear, in numerals not less than three (3) inches high, the District's fan designation numbers. The plate shall be securely screwed or riveted to the exterior of the fan housing adjacent to the fan nameplate.

C. Each motor shall be provided with two identical stainless steel nameplates permanently stamped with the name and address of the motor manufacturer, the motor horsepower, NEMA motor frame number, voltage, phase, frequency, insulation type, full-load current, locked rotor indicating code letter, minimum overall efficiency, the design temperature rise over ambient of the motor, maximum ambient temperature, type of duty, the terminal connection chart for the motor, rating of space heater, speed in revolutions per minute, service factor, motor type and serial number, maximum starts per day, ABMA bearing code and shop order number. One nameplate shall be furnished on the motor and the other either riveted or screwed on the exterior of the fan housing immediately adjacent to the fan nameplate.

D. Each fan shall be provided with a 10-inch-long by 1 1/2-inch-wide metallic arrow that shall indicate the direction of forward and reverse airflow. The arrows shall be rigidly and permanently attached to the fan housing, in a position that can be readily viewed when the fan is in its final operating position. Three-quarter-inch letters shall be engraved on the arrow to read as follows: “EXHAUST (FORWARD AIRFLOW)” and “SUPPLY (REVERSE AIRFLOW).”

E. Each fan shall be provided with a 10-inch-long by one-inch-wide stainless steel plate permanently stamped with the labels “Grease Line Supply Port” and “Grease Line Exit Port”.

F. All the nameplates shall be Type 316 stainless steel of not less than 10-gauge-thick and shall be placed to be readily conspicuous after installation.

2.08 FACTORY TESTS AND INSPECTIONS

A. General

1. Contractor shall perform factory tests and inspections as described below. The District may, at their option, witness any or all tests. Observations made during the tests and all test results shall be recorded in a document form, certified by Contractor and submitted to the District Representative for approval. No less than three weeks written notice shall be furnished to the District Representative before the factory tests. No test notification shall be sent until all of the factory test procedures have been submitted, reviewed and approved.

2. Tests described herein shall not preclude additional standard tests normally performed by the manufacturers for similar equipment.

3. Pre-production fan-motor units used for testing may be furnished as production units after pre-production testing if the units satisfactorily pass all specified factory tests as described below under production fan tests, except for fan-motor units subjected to the elevated temperature test. Motors, motor shafts, and fan rotating assembly components used in the elevated temperature test shall not be furnished in production fan motor units.

4. All of the pre-production tests shall be performed for each fan-motor unit model supplied. All of the pre-production test results shall be submitted and accepted by the District prior to the start of construction of the production fan-motor units. The Pre-production tests include the overspeed test, vibration test, elevated temperature test, air performance test, non-destructive inspections (NDI), strain test, sound test, reversal test and running (200 hr) test. Production tests include overspeed test, vibration tests, run-in (24 hr) test, NDI test.

5. All fan performance tests, production and pre-production shall utilize a motor control center (MCC) and power supply source similar to the power supply and motor controller being provided, under the Contract, at the actual field installation. Increasing the transformer tap, doubling up on transformers or similar modifications to the fan motor power supply shall not be acceptable.

6. The test procedures shall be performed for each fan-motor unit model supplied.

7. The tests shall be sequential in the order prescribed below. Any fan-motor unit or component that fails to satisfactorily perform any test as specified shall be considered unacceptable. Failing parts shall be replaced and the entire unit shall be re-tested.

8. Before actual testing is begun on any fan-motor unit to be furnished, Contractor shall submit full details of all test procedures including the sequence in which they are to be run and the expected duration of the test, samples of all test report forms, and full details of the methods by which the raw test data is to be reduced for submittal to the District Representative for approval.

9. Test details shall also include a list of test instrumentation, containing name of manufacturer, model type, serial number, and calibration date. Documentation shall be furnished to verify that test instrumentation has been calibrated not more than nine months before the tests.

10. Except as required for the independent motor factory test, all tests shall be performed by Contractor at the fan manufacturer’s plant or other District Representative approved location.

11. All expenses in connection with or incidental to the factory testing shall be borne by Contractor.

B. Motor Tests

1. Motors shall be tested in accordance with the procedures specified in IEEE Publication 112 and NEMA MG-1. Using full voltage option, motor tests shall be performed for one pre-production motor of each size by an independent testing company approved by the District. Tests performed for the pre-production motor by the motor manufacturer will not be acceptable. This shall not preclude preparatory testing at the manufacturer's facility prior to conducting the independent motor factory test. A certified test report and certified performance curves verifying the theoretical motor performance curves for all of the coordinates specified shall be submitted to the District Representative for approval. Performance curves for each type and size of fan motor shall be plotted to a scale that will facilitate accurate readings. The District Representatives may, at their option, witness the independent motor factory tests.

2. One motor of each nameplate horsepower rating and service factor shall be tested for forward and reverse modes as follows:

    a. Full voltage tests to obtain actual fan motor performance curves from standstill to full speed verifying the theoretical fan motor performance curves at 110 percent, 100 percent, 90 percent and 85 percent rated voltage previously submitted and other data specified hereinafter.

        1) Full-load current in amperes
        2) No-load current in amperes
        3) Full-load input in kilowatts
        4) No-load input in kilowatts
        5) Locked-rotor current in amperes
        6) Locked-rotor input in kilovolt amperes
        7) Locked-rotor, pull-up and breakdown torque in foot-pounds

    b. Tests to determine:

        1) Winding resistance
        2) Losses, no-load and full-load
        3) Temperature rise - motor thermal curves
        4) Dielectric tests
        5) Visual bearing inspection

3. Heat Run Test

    a. Each pre-production motor shall be connected to a dynamometer, loaded to design duty and operated continuously until winding and bearing temperatures stabilize.

b. Temperatures shall be considered stabilized when no more than a one-degree Celsius increase in temperature is observed over a one-half hour period. Winding and bearing temperatures shall be recorded on one-half hour intervals throughout the test.

c. Production motors and spare motors for each size specified shall not be released for manufacture until the pre-production motor has satisfactorily completed the independent motor factory test, the heat run test and the high temperature test.

4. The remaining motors shall be tested at their rated synchronous speed in both the forward and reverse direction. Tests shall include the following:

   a. Winding resistance

   b. No-load current in amperes

   c. Dielectric tests

   d. No-load speed

   e. Visual bearing inspection

   f. Locked-rotor current in amperes

5. The following data shall be plotted for each speed and direction as ordinates versus horsepower as abscissas from no load up to not less than 115 percent full load:

   a. Current, in amperes

   b. Efficiency, in-percentage

   c. Power factor, in-percentage

6. The following data shall be plotted for each motor horsepower size as ordinates versus revolutions per minute as abscissas:

   a. Current in amperes

   b. Torque in foot-pounds

   c. Power factor in percentage

7. Test data for the certified performance curves shall be recorded at the rated voltage and frequency of the motor, continuously over the speed range from standstill to rated rotational speed of the motor.

C. Elevated Temperature Test

1. One pre-production fan-motor unit of each size provided shall be installed in an elevated temperature duct loop and subjected to Design Temperature Conditions Article 1.09A herein.

2. The fan-motor unit shall be operated at design airflow and pressure during the test.

3. Air temperature in the heat loop shall be recorded continuously throughout the test.

4. Motor winding and bearing temperatures, voltage and current shall be measured and recorded at a minimum of five-minute time intervals throughout the test.

5. Each fan-motor unit shall still be operating at the design duty at the end of the elevated temperature test with no rubbing of the fan blade tips against the interior of the fan casing. In the event that expansion of the fan blades due to increased temperature results in any blades contacting the casing, the Contractor shall ensure that the manufacturer submits a remediation plan to the District Representative for approval.

D. Non-Destructive Inspection

1. Radiographic Inspection

   a. Provide a certification that, for all fan hubs and blades, x-rays have been taken in accordance with ASNT standards, with notation of the x-ray numbers, and also that fluorescent dye penetrant examination has been performed. In addition, provide a complete list of the identification numbers for all hubs and blades actually installed in each fan.

   b. Certification of visual acceptability, the x-ray procedure, the x-ray films, and proof of traceability of conformance with alloy specifications of the metal used to cast the hub and blades shall be submitted to the District Representative for approval. The identification number of the x-ray film shall be etched on each blade and hub at a location that will not create adverse stress concentrations to reduce the design safety factor at the point of critical stress.

   c. The x-ray films shall be kept on file by the manufacturer for a minimum of five years.

2. Ultrasonic Examination

   a. Provide certification that, for all forged fan hubs and blades, ultrasonic examination has been performed in accordance with ASTM A 388. In addition, provide a complete list of the identification numbers for all hubs and blades actually installed in each fan.

   b. Certification of visual acceptability, the ultrasonic examination procedure, and proof of traceability of conformance with alloy specifications of the metal used to forge the hub and blades shall be submitted to the District Representative for approval.

   c. The ultrasonic examination results shall be kept on file by the manufacturer for a minimum of five years.

3. Magnetic Particle Examination

    a. Provide certification that, for all forged fan hubs and blades, mag. particle examination has been performed in accordance with ASTM E 709. In addition, provide a complete list of the identification numbers for all hubs and blades actually installed in each fan.

    b. Certification of visual acceptability, the mag particle examination procedure, and proof of traceability of conformance with alloy specifications of the metal used to forge the hub and blades shall be submitted to the District Representative for approval.

E. Overspeed Tests

1. All fan rotor assemblies shall be subjected to an overspeed test before assembly of the complete fan motor units.

2. After non-destructive inspection and after static and dynamic balancing, each completely assembled fan impeller shall be overspeed tested in both directions. Spin testing of individual components, such as blades and rotors, in lieu of testing complete impellers, is not acceptable. Each fan impeller shall be spun from standstill up to 125 percent of the maximum design operating speed for a period of not less than three minutes. Following each spin test, a visual inspection for surface defects shall be made by Contractor. Certificates of visual acceptability shall be submitted to the District Representative for approval.

F. Vibration Tests

1. After assembly, each fan-motor unit shall be checked for bearing operation in both directions of rotation. Defective bearings shall be replaced, and the fan shall be re-checked before further testing. The vibration shall be measured in two radial planes, 90 degrees apart, and in the axial direction. Measurements shall be made for each radial plane at the front and rear of the fan. Measured maximum vibration shall not exceed peak-to-peak amplitudes of 0.35 mils (0.00017 inch) for fans operating at a nominal speed of 1,200 rpm or less.

2. If measured vibration amplitude exceeds the specified maximum, or if the specified vibration measurements reveal unacceptable vibration at any frequency other than rated design operating speed, vibration amplitude shall be measured and recorded continuously as the fan is accelerated from a standstill to rated design operating speed, and as the unit coasts down from rated design operating speed to a standstill. The amplitude versus frequency chart shall be analyzed by Contractor (Fan Manufacturer) to determine the cause(s) of the unacceptable excessive vibration. Resonant frequencies shall be determined and shall be demonstrated as not to occur within fan operating ranges. The analysis shall be submitted to the District Representative for approval and the cause(s) shall be corrected. The District Representative shall be furnished final vibration amplitude readings on all fan bearings.

G. Fan-Motor Unit Performance Test

1. One pre-production fan-motor unit which has satisfactorily passed the preceding test and inspections specified, shall be tested in accordance with the procedures specified in the AMCA 210, latest edition, using a test set-up approved by the District Representative.

2. Fans shall be tested without flow cones or any other static regain devices. The fans shall be tested at the blade angle that shall produce the required volume of air at the required system pressure, and the minimum and maximum blade angle. Test data shall be recorded on AMCA data submittal forms, or the equivalent thereof, as approved by the District Representative. Certified test data, and certified performance curves for all of the coordinates specified shall be submitted to the District Representative for approval.

3. Performance tests shall cover the range of airflow rates from no flow to free air delivery. Performance tests of ventilation fans shall cover this range of airflow rates in both directions of airflow. Actual fan performance shall not be less than Contract values.

4. Performance tests shall include starting fan from a standstill against a system resistance that will result in the fan operating at the airflow and pressure indicated on the fan schedule. Starting tests shall be performed for both forward and reverse airflow directions at rated voltage, 90 percent of rated voltage and 85 percent of rated voltage. A Power Quality Analyzer shall be used to measure and record current, voltage, power factor and power versus time during starting from standstill to a period of five (5) minutes after fan reaches rated speed, with meter set to measure and record data on one-second intervals.

5. The fan shall be calibrated for airflow capacity versus annulus velocity, using laboratory grade pitot tube in the annulus and mounted through the bushing in the fan housing during performance test.

6. Triaxial Strain gauges shall be applied to two blades per impeller and to the hub of the unloaded impeller of each fan. To accurately measure strains and stresses developed in each rotor, one strain gauge at the midpoint and one strain gauge at the tip of blades on each side shall be applied on minimum of two blades. In addition, one strain gauge shall be applied on impeller hub for each strain-gauged blade. The strains developed during performance testing shall be continuously measured and monitored. The measured strains produced under the performance test load shall be used to calculate the corresponding stresses. Stresses found shall not exceed 60 percent of the material yield strength at 482 degrees Fahrenheit. The methods of strain measurement and stress calculation shall be submitted to the District Representative for approval. Contractor shall submit the manufacturer’s certification that the measured strains and the corresponding calculated stresses represent the strains and stresses developed in all other blades of the pre-production fan motor unit being tested. Calculated maximum expected stresses, and the design properties of the material used to fabricate the impeller blades and hub, shall also be submitted to the District Representative for approval. Strain gauge testing shall be performed using the same testing set-up and operating conditions as the fan full-scale

performance test, and shall be performed at the design duty blade angle setting with the fan operating at the design duty airflow and pressure.

7. In the event that the tests show that the fan-motor units do not comply with the requirements as to characteristics and performance, or that the brake horsepower will exceed by five percent or more the brake horsepower shown in the theoretical data submitted by Contractor, the fan motor units will be rejected until the specific requirements are met.

8. Upon the completion of the fan-motor units performance tests, submit two complete copies of all raw test data.

9. After the completion of fan-motor units performance tests, submit for each fan-motor unit model supplied, performance curves and tables of performance data calculated from shop test data for each blade angle tested, at each of the test points at each rotational direction and speed.

10. The tables shall consist of numerical values at each of the test points for the following:

    a. Volume of air delivery in cubic feet per minute

    b. Fan static pressure in inches of water

    c. Fan total pressure in inches of water

    d. Fan outlet velocity pressure in inches of water

    e. Fan total efficiency in percent

    f. Horsepower input to fan impeller

    g. Fan speed in revolutions per minute

    h. Current input in amperes versus time for fan starts at rated voltage, 90 percent of rated voltage and 85 percent of rated voltage

    i. Voltage in volts versus time for fan starts at rated voltage, 90 percent of rated voltage and 85 percent of rated voltage

    j. Power factor for fan starts at rated voltage, 90 percent of rated voltage and 85 percent of rated voltage

    k. Motor power input in kilowatts and power factor rated voltage, 90 percent of rated voltage and 85 percent of rated voltage

    l. Number of phases and frequency

11. Submit fan-motor unit performance curves verifying the theoretical performance curves previously submitted. Test points shall be indicated on performance curves.

12. Submit all electrical curves for fan starting testing.

H. Sound Test

1. Pre-production unit which has satisfactorily passed all preceding tests and inspections specified shall be tested at the design duty on the performance test set up in accordance with the test procedure of ANSI S12.36 to obtain sound power level data at eight octave band center frequencies from 63 Hertz to 8,000 Hertz.

2. Fan shall be tested at the design duty blade angle setting with the fan operating at the design duty airflow and pressure in both forward and reverse directions. Test data shall be submitted to the District Representative for approval in tabular form.

I. Reversal Test

1. One pre-production fan-motor unit for each size supplied which has satisfactorily passed all preceding tests and inspections specified shall be subject to reversal tests. These tests shall require operation at rated operating speed at the approximate design duty airflow and pressure for approximately three and a half hours, and shall require three cycles of rotation reversal. A cycle of rotation reversal is defined as reversal from one direction of motor impeller rotation to the other direction of rotation, and then back to the first direction of rotation.

2. The reversal test shall begin with the fan-motor unit operated for a period of 30 minutes in the forward direction of airflow.

3. At the end of the first 30-minute period of operation in the forward direction of airflow, the motor shall be electrically reversed, with a 10-second time delay imposed between the interruption of power and re-energizing of the motor for reversed rotation. The fan shall achieve full speed rotation in a maximum of 15 seconds after re-energizing the motor for reverse rotation.

4. After the motor has been re-energized, the fan shall be operated for a period of 30 minutes in the reverse direction of airflow.

5. The test shall be continued, with alternating 30-minute periods of operation in the forward and reverse directions of airflow, until six rotation reversals have been performed. At the end of each 30-minute period of operation, the fan-unit motor shall be electrically reversed, with a 10-second time delay imposed between each change in direction until six rotation reversals have been performed. The fan shall achieve full speed rotation in a maximum of 15 seconds after re-energizing the motor for reverse rotation.

6. After three cycles of rotation reversal, i.e., six reversals of the direction of motor and impeller rotation have been performed, the fan-motor unit shall be operated for a period of 30 minutes.

7. At the end of the last 30-minute period of operation, the fan shall be de-energized, and permitted to coast to a standstill.

8. Resistance of the cold motor winding insulation shall be measured just before the start of the reversal test, and the motor winding insulation shall be measured immediately after the end of the test. In addition, the temperature of the motor windings and of the motor frame shall be continuously recorded throughout the test and the acceleration time, speed, voltage, frequency, amperes, and kilowatts shall be recorded during each reversal. Certification of successful performance of the reversal test and certified test data shall be submitted to the District Representative for approval.

J. Pre-production Running Test: One pre-production fan-motor unit for each size supplied which has satisfactorily passed all preceding tests and inspections specified shall be operated continuously for 100 hours in the forward direction of airflow, de-energized and allowed to coast to a stand-still, then re-energized and operated continuously 100 hours in the reverse direction of airflow. The fan-motor unit shall be checked for rough operation, as a minimum, every 10 hours and a record made of each check. This record shall be included in the completed fan test records.

K. Run-In Test: Each ventilation fan shall be operated continuously for a total of 24 hours, 12 hours in the forward (exhaust) mode and 12 hours in the reverse (supply) mode of rotation. During reversal, fan shall be allowed to coast for a period of five minutes before being restarted in the reverse direction. Fans which have passed the Pre-production Running Test will be deemed to have passed this test. The following data shall be measured and recorded after each fan reaches rated speed and at one-hour intervals thereafter:

1. Time.
2. Ambient temperature in degrees Fahrenheit.
3. Absolute barometric pressure in inches of Mercury.
4. Motor winding temperatures in degrees Celsius.
5. Motor bearing temperatures in degrees Celsius.
6. Motor bearing vibration levels in inches per second.
7. RPM (revolutions per minute).

PART 3 – EXECUTION

3.01 INSTALLERS

A. The District Representative shall be advised in writing of the name and title of the proposed manufacturer’s field service engineer, who upon District Representative approval shall have complete authority to represent and to act for Contractor.

B. Contractor shall ensure that the manufacturer’s field service engineer assists the Contractor with the installation of the fan-motor units.

C. Equipment shall be installed in accordance with the approved Shop Drawings and the respective equipment manufacturers' installation instructions and recommendations.

3.02 EXAMINATION

A. Prior to installation, the Contractor shall measure or survey the facilities and prepare a layout and section drawing showing the centerline of installation and top of foundation elevations. The horizontal centerline shall be based on the centerline of the tunnel-side opening frame. Vertical control shall be based on the tunnel-side opening frame such that all pieces line up with the tunnel-side opening. Submittal and approval of this layout and section drawing is required before installation can proceed.

B. Contractor shall note any items that may infringe on the necessary clearances for the equipment.

3.03 PREPARATION

A. Ventilation equipment shall be carefully protected at the Jobsite in a manner to preclude the possibility of damage to the equipment.

B. The permanent anti-condensation motor space heaters for the fan motors and the damper motors shall be energized with temporary power before and after installation until permanent power is available. Contractor shall energize the motor space heaters within 24 hours after the fan is delivered to the Jobsite.

C. Construct all concrete pads, supports, and foundations necessary to support the equipment. Provide all anchor bolts, rebar ties, and sleeves. Anchor bolt sleeves shall allow for minimum 1/4-inch movement of the anchor bolts. Anchor bolt sleeves under rubber pads shall allow for the thickness of any vibration isolation sleeves. These foundations shall allow for a nominal 3/4-inch thick grout to be placed under the equipment support.

3.04 ERECTION

A. The manufacturer's rigging instructions shall be carefully followed.

B. Set equipment in place to the indicated lines and levels. Shim to required levels with stainless steel shims. All flange faces shall be aligned and parallel prior to bolt-up. Flexible joints shall only be installed after all hard flange joints are connected and shall be used only to close aligned parallel connections between hard flanges. Flexible joints shall not be used to correct misalignment conditions.

C. Where rubber pads are specified under rotating equipment for vibration isolation, provide a minimum 1/2-inch thick continuous steel plate underneath the pad to allow the equipment to be set on shims prior to grouting. Holes for anchor bolts shall allow for any vibration isolation sleeves or washers.

D. When installed, the orientation of each fan, as to motor end, shall be as indicated on the Contract Drawings.

3.05 INSTALLATION

A. Fans shall be connected to transition companion flanges with 1/4-inch-thick solid gasket between; width of gaskets shall be same as flange width.

B. Apply anti-seizing compound to the threads of stainless steel bolts and studs.

C. After all bolt-ups are completed and accepted, grout all foundations and anchor bolt sleeves.

D. After installation and before the start of testing, the equipment shall be lubricated. Equipment shall be checked for clearances and proper alignment.

E. Perform all non-power alignment, adjusting, and testing as required by the respective manufacturer's installation procedures.

3.06 ELECTRICAL AND CONTROLS

A. All interconnecting power and wiring between ventilation components shall be installed, terminated, and tested by the Contractor. Contractor shall provide access to equipment and resolve discrepancies in ventilation equipment as required.

B. Inspect all power and control wire connections and perform all continuity testing to ensure proper installation, and meger testing to ensure insulation integrity is maintained after installation is completed. Perform all functional alignment, adjusting, and testing as required by the equipment manufacturer's instructions.

C. When the electrical installation work is completed and verified, advise the District Representative so that field tests can be performed. After field testing is completed, restore all equipment to its proper operating condition.

D. All power and control wiring external to the ventilation equipment shall be provided by the Contractor.

3.07 FIELD QUALITY CONTROL

A. All installation procedures shall conform to the equipment manufacturer's instructions. Checklists shall be used and signed off by the responsible installer as well as by the respective equipment manufacturer's representative.

B. Contractor shall provide the manufacturer's field service engineering and inspection reports to District Representative to ensure that the fans are properly installed and tested.

C. Field service shall be performed periodically as required during the construction and testing of the District's Contract. Field service shall not be less than 14 Days.

D. The duties, responsibilities, and qualifications of the field service engineer shall be:

E. Responsible for advising the installation Subcontractors on the proper procedures for the installation of the fan equipment.

F. To have a thorough knowledge of the ventilation fans and the associated systems.

G. To have a thorough knowledge of the test results and performance requirements of all material and equipment supplied.

H. To prepare and submit to the District a typewritten report on the activities and findings for each visit made within 15 Working Days of the visit.

3.08 FIELD TEST

A. Upon completion of the installation of all ventilation equipment at the fan room and the installation and verification of the power and local control wiring, Contractor shall notify the District Representative in writing at least four weeks before the field testing to have the District Representative present to witness the tests. Contractor shall also notify the field service engineer for assistance in the performance of the tests. Contractor shall submit field test procedures for testing of the fan motor units in the field.

B. Contractor shall ensure that field tests are performed under the technical guidance and supervision of the manufacturer's field service engineer. The field service engineer shall provide the field test instrumentation and perform the tests. The field service engineer shall measure and record the vibration amplitude; power consumption; no-load, starting and full-load voltages; starting and full-load currents; and acceleration time.

C. Time of field run-in testing shall be one hour per fan in each direction. Vibration and electrical measurements shall be recorded for each fan motor unit at design speeds in each direction. Where multiple fans are installed in the same room, all fans shall be operating simultaneously when recording vibration and electrical data.

D. Field testing for the ventilation equipment shall not commence until permanent electric service and local controls can be provided for testing.

E. Visual and operating tests required are as follows:

1. Each fan-motor unit shall be checked for obviously rough operation after the fans are installed. Defective bearings shall be replaced with new bearings and the fan(s) shall be re-checked. Amplitude and frequency of radial and axial vibrations at the bearings shall be measured, recorded, and checked for conformity to these Specifications.

2. Each fan-motor unit on which the specified vibration field tests have been successfully performed shall be tested to confirm that such fans are fully operational.

3. Each ventilation fan-motor unit shall be proven operational in both directions of airflow. One full reversal test shall be performed on each installed fan. The field reversal test shall include one 30 minutes of forward operation, followed by de-energizing for 10 seconds, followed by re-energizing in the reverse direction of rotation for 30 minutes. The fan shall achieve full speed rotation in a maximum of 15 seconds after re-energizing the motor for reverse rotation. These tests shall be measured, recorded, and checked for conformity to these Specifications.

4. Verify proper operation of the proximity probes and all fan operation instrumentation equipment indicating the direction and speed of rotation of the fans. This would include proximity, phase rotation, current and pressure sensing equipment. These tests shall be measured, recorded, and checked for conformity to these Specifications.

5. Field measurements required are as follows:

F. Tunnel Airflow Performance Test: The last portion of the field tests shall be the measurement of air movement within the tunnel produced by the ventilation system.

1. The District Representative shall provide Contractor with details on locations for the measurements, the testing conditions (such as ventilation system operating requirements and the location of stopped trains), and the test results required for each location at least 180 Days before the scheduled date of test initiation. Air velocity measurements of the entire tunnel cross section shall be performed in order to measure the average airflow (in standard cubic feet per minute) through the cross section as determined by the log-Tchebycheff (log-T) rule. For each measurement location, a minimum of two air velocity measurements of the entire cross section shall be taken and averaged, and the averaged measurements shall not vary by more than two percent. If two sets of measurements vary by more than two percent, additional measurements shall be taken until two consecutive sets of measurements do not vary by more than two percent. The measurements shall account for the effects of the tunnel portals, changes in horizontal curvature, and location and distance from the stopped train. Contractor shall make the necessary arrangements with the District Representative to schedule the tests and to use stopped trains during the actual testing period. Train locations shall be as determined by the District Representative before testing.

2. Contractor shall submit to the District Representative, for approval by the District Representative, a written test program at least 45 Days before the scheduled date of test initiation and meeting the requirements of Contract Specifications Section 23 05 93, Testing, Adjusting, and Balancing for HVAC. This test program shall contain, as a minimum, the resumes of the Key Personnel participating in the test phase, the specific make and model numbers of the test equipment to be used, and a specific and detailed procedure to be followed for the set up of equipment and for the sampling, recording, and reduction of the test data.

3. Contractor shall provide the District Representative with the measured test results. If the District Representative determines that the measured air velocities are less than the required "cold" air velocities, Contractor shall be notified in writing to increase the fan blade angles in order to produce the required tunnel airflow velocities. The field measurements shall then be repeated in order to verify that the required tunnel airflows have been achieved. If the increased fan airflows cause overloading of the fan motors, Contractor shall advise in writing on the extent of the overload.

4. The District Representative shall be notified in writing at least two weeks before the initiation of this testing phase in order to coordinate the use of train(s) and to program the appropriate ventilation system operation.

5. Sound Test: Sound pressure levels, measured in dB(A) shall be measured and recorded at platform level near each fan room with all Station fans operating. Background sound pressure levels shall be recorded before and after any fan noise measurement. Sound pressure levels shall be recorded in each octave band.

6. These tests shall be performed by qualified personnel (employees of Contractor or a Subcontractor) who have been approved by the District Representative. The overall responsibility for this measurement program shall belong to Contractor.

7. Air velocity measurements shall be made in each tunnel ventilation zone (between vent structures and between vent structures and stations or portals) of the entire tunnel. Cross sections shall be performed in order to measure the average airflow (in standard cubic feet per minute) through the cross section as determined by the log-Tchebycheff (log-T) rule. For each measurement location, a minimum of two air velocity measurements of the entire cross section shall be taken and averaged, and the averaged measurements shall not vary by more than two percent. If two sets of measurements vary by more than two percent, additional measurements shall be taken until two consecutive sets of measurements do not vary by more than two percent.

G. After completion of all field tests and after the final visit by the field service engineer, Contractor shall submit a field test and inspection report. Field test report shall include copies of raw data, measured results, calculations, and all data derived from tests to confirm compliance with specified performance, noise, vibration and equipment efficiencies.

3.09 PROTECTION

A. Fans shall be allowed to free wheel until beneficial use is accepted. Contractor shall protect openings to prevent unauthorized access.

END OF SECTION 23 34 14

SECTION 23 81 00

UNITARY HVAC EQUIPMENT

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Split-type air source heat pumps.

B. Rooftop packaged air-conditioning units or air-source heat pumps.

C. Split system air conditioning units.

D. Heating and ventilating units.

E. Hot water boilers.

F. Recirculation pumps.

G. Air coils.

H. Electric cabinet convector.

I. Electric unit heater.

J. Hot water unit heater.

K. Gas fired unit heater.

L. Infrared tube heaters.

M. Infrared hi intensity heater.

N. Rooftop indirect evaporative air cooler.

O. Gas fired furnace.

P. Cooling tower.

Q. Air filters.

R. Boiler stack.

1.02 RELATED SECTIONS

A. Section 01 33 00, Submittal Procedures

B. Section 01 33 23, Shop Drawings, Product Data, and Samples

C. Section 01 42 19, Reference Standards

D. Section 01 45 00, Quality Control

E. Section 01 78 23, Operation and Maintenance Data

F. Section 01 79 00, Demonstration and Training

G. Section 03 61 11, Non-Shrink Grout

H. Section 05 50 00, Metal Fabrications

I. Section 09 91 00, Painting

J. Section 20 10 13, Common Materials and Method for Facility Services

K. Section 20 30 13, Vibration Isolation and Seismic Control

L. Section 20 60 13, Motors for Facility Services

M. Section 23 05 93, Testing, Adjusting, and Balancing for HVAC

N. Section 23 23 00, Refrigerant Piping

O. Section 23 31 00, HVAC Ducts and Casings

1.03 MEASUREMENT AND PAYMENT

A. General: Separate measurement or payment will not be made for the Work required under this Section. All costs in connection with the work specified herein will be considered to be included or incidental to the Work of this Contract.

1.04 REFERENCES

A. Air Conditioning and Refrigeration Institute (ARI):

1.	ARI 210/240	Unitary Air-Conditioning and Air-Source Heat Pump Equipment
2.	ARI 270	Sound Rating of Outdoor Unitary Equipment
3.	ARI 310	Packaged Terminal Air Conditioners
4.	ARI 340	Commercial and Industrial Unitary Heat Pump Equipment
5.	ARI 360	Outdoor Air-Conditioning Equipment
6.	ARI 380	Packaged Terminal Heat Pumps
7.	ARI 410	Standard for Forced Circulation Air-Cooling and Air-Heating Coil
8.	ARI 430	Standard for Central Station Air-Handling Unit

B. Air Movement Contractor's Association (AMCA):

1. AMCA 99 Standards Handbook
2. AMCA 210 Laboratory Methods of Testing Fans for Rating
3. AMCA 300 Reverberant Room Method for Sound Testing of Fans
4. AMCA 301 Methods for Calculating Fan Sound Ratings from Laboratory Test Data
5. AMCA 500D Laboratory Methods Testing for Dampers for Rating
6. AMCA 500L Laboratory Methods Testing for Louvers for Rating

C. American Gas Association (AGA):

1. Directory of Certified Appliances and Accessories
2. Z21.13 Gas-Fired Low Pressure Steam and Hot Water Boilers

D. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE):

1. ASHRAE 14 Measurement for Energy and Demand Savings
2. ASHRAE 15 Safety Standard for Refrigeration Systems
3. ASHRAE 52.1 Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter

E. American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessels Code (BPVD):

1. ASME BPVC SEC IV Rules for Construction of Heating Boilers
2. ASME BPVC SEC VIII Rules for Construction of Pressure Vessels

F. Anti-friction Bearing Manufacturer's Association (ABMA)

1. ABMA STD 9 Load Ratings and Fatigue Life for Ball Bearings
2. ABMA STD 11 Load Ratings and Fatigue Life for Roller Bearings

G. ASTM International (ASTM):

1. ASTM E84 Test Method for Surface Burning Characteristics of Building Materials

H. Cooling Technology Institute (CTI):

1. CTI ATC-105 Acceptance Testing Code

I. Hydronics Institute (HI)

1. Testing and Rating Standard for Cast Iron and Steel Heating Boilers.

J. National Electrical Manufacturer's Association (NEMA):

1. NEMA 250 Enclosure for Electrical Equipment
2. NEMA ICS 1 Industrial Control and Systems General Requirements
3. NEMA MG 1 Motors and Generators

K. National Fire Protection Association (NFPA):

1. NFPA 54 (AGAZ 223.1) National Fuel Gas Code
2. NFPA 90A Standard for the Installation of Air Conditioning and Ventilating Systems
3. NFPA 70 National Electrical Code (NEC)

L. Sheet Metal and Air Conditioning Contractors National Association

1. SMACNA HVAC Duct Construction Standards

M. Underwriters Laboratories Inc. (UL):

1. UL 378 Draft Equipment
2. UL 726 Oil-Fired Boiler Assemblies
3. UL 900 Air Filter Units
4. UL 1995 Heating and Cooling Equipment

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit Shop Drawings indicating plans, elevations, and sections; dimensions and weights of equipment; sizes of refrigerant piping connecting to and from equipment; electrical connections; wiring diagrams; control logic diagrams (sequence of events) product data for instruments and controls; safety devices; condensate drain; interlocks; and concrete pads.

C. Product Data: Submit manufacturer's product data indicating total installation instructions, assembly support details thermal loads including sensible and total loads where applicable, motor horsepower and kilowatt rating, electrical characteristics, sequence of operation, type of refrigerant, pressures, suction and condensing temperatures, connection requirement, performance curves, start-up instruction and installation, testing procedures and start-up instructions.

D. Operation and Maintenance Data: Submit manufacturer's printed operation and maintenance instructions, in accordance with Section 01 78 23, Operation and Maintenance Data, describing operating procedures and maintenance sequences. Include manufacturer's recommended spare parts list for maintenance requirements.

E. Warranties: Submit the respective manufacturer's warranty, warranting the performance of the equipment for a two-year period following final acceptance of the work, and for a 12-month period after the equipment is put into normal and continuous operation. Furnish labor, materials and equipment to adjust the air conditioning and heating equipment during the warranty period.

1.06 QUALITY ASSURANCE

A. Provide products and installation conforming to NFPA 70, National and the California Electrical Code; ASHRAE 15, and the California Mechanical Code.

B. Provide products of manufacturers specializing in the manufacture of HVAC equipment, that can show evidence of having produced HVAC equipment of approximately the same required capacity, and has been in successful operation for at least ten years.

C. Test and rate the air-conditioning equipment and heat pumps in accordance with ARI 210/240, 310, 340, and 380 as applicable.

D. Equipment shall be manufactured and tested in accordance with applicable UL requirements.

E. Work Quality: Conform to applicable requirements of AMCA 99.

1.07 SITE CONDITIONS

A. Examine surfaces and structures where equipment will be installed before the Work of this Section begins, assuring that the surfaces are capable of supporting the weight of the equipment. Any deviation or discrepancies of the site conditions from the contract, the contractor shall notify the District within 48 hours. Surfaces that will become inaccessible after the equipment installation shall be completed before the equipment is installed. Assure that electrical facilities and services, that serve the equipment, have been installed, tested, and approved before installation of equipment.

PART 2 – PRODUCTS

2.01 GENERAL PRODUCT REQUIREMENTS

A. Built-in thermostats furnished with heating and cooling equipment shall meet requirements of the CCR Title 24, California Energy Code, Part 6, Subchapter 2, All Occupancies – Mandatory Requirements for the Manufacture, Construction and Installation of Systems, Equipment and Building Components.

B. Minimum efficiency of cooling equipment shall meet or exceed requirements of the CCR Title 24, Part 6, Sub chapter 2, “Mandatory Requirements for Space-Conditioning Equipment and Table 1-C, Efficiency Requirements for Space-Conditioning Equipment.

C. Cooling equipment shall be listed on the California Energy Commission’s (CEC) list of approved equipment and shall be certified, by the manufacturer, as complying with the CEC Appliance Efficiency Standards.

D. Air conditioners and heat pumps shall be designed for and charged with non-ozone-depleting refrigerant as specified in Section 23 23 00, Refrigerant Piping. Hydrogenated Chlori-Flouride Carbon (HCFC) and Non Chlori-Flouride Carbon (CFC) Refrigerant except as indicated.

E. Disconnect switches, where provided, shall be accessible from outside control panel with control circuit transformer wired on disconnected side of the switch.

F. Provide smoke detectors for air conditioning equipment to automatically shut-down the system upon detecting the presence of smoke as required by NFPA 90A, and connect to equipment controls and fire alarm system and connect to equipment controls and existing fire alarm system.

G. Motors shall be premium, highest efficiency, and shall be furnished in accordance with the requirements of Section 20 60 13, Motors for Facility Services.

H. Dampers and louvers shall be rated in accordance with AMCA 500D and 500L, respectively.

2.02 THROUGH WALL TYPE AIR CONDITIONING UNITS AND HEAT PUMPS

A. Provide factory assembled and tested units designed for mounting through wall. Provide air cooled, cooling only, or combination electric heating and cooling units of either the section type or integrated type as applicable and as defined in ARI 310, or ARI 210/240, heat pumps, as indicated. Provide units rated in accordance with ARI 310 or 380 producing not less than indicated capacities.

B. Unit shall include fans and motors, integral temperature controls, outdoor louver, wall sleeve, 1 inch throwaway air filter, accessories for controlled ventilation and condensation removal, and electrical box for external power connection.

C. Provide unit enclosure of minimum 18 gage galvanized steel, finished with baked enamel. Front panel shall be removable without the use of tools. Access to unit controls shall be gained by an access panel. Provide four way adjustable discharge grilles. Provide return air entering between either kick plate and front panel or a low level in front panel. Line interior of enclosure with insulation having a fire hazard rating of not more than 25 for flame spread and 50 for smoke developed as determined by ASTM E84.

D. Provide horizontal bar type louvers with flanged louver plate assembly constructed of 14 gage aluminum, anodized after fabrication.

E. Provide one piece casing, self bracing, fabricated of not less than 16 gage zinc coated steel, phosphatized and finished with baked enamel. Design wall sleeve for field installing and fastening to outside air louver with a positive weather and air tight seal.

F. Provide electric resistance heating coil, where indicated, having factory mounted, automatic resetting, high limit safety device wired to chassis. Safety device shall shut off heating unit when heating unit temperature exceeds manufacturer's recommended heating limit.

G. Provide self contained cooling section, either slide in assembly or removable chassis type, hermetically sealed refrigeration compressor, separate condenser fan and motor, evaporator fan and motor, control box, condensation drain pan, and ventilation damper. Cooling section shall include refrigeration circuit tubing, wiring and safety controls, and shall be constructed as follows:

1. Provide permanent split capacitor type motor, having an overload protection and fused capacitor.

2. Condenser coil shall have copper tubes and aluminum fins. Fins shall be mechanically bonded to tubes.

3. Evaporator coil shall have copper tubes and aluminum fins. Fins shall be mechanically bonded to tubes, and shall be positioned above an insulated galvanized steel drain pan.

4. Condenser and evaporators shall each have one or more resiliently mounted fans. Fans shall be statically and dynamically balanced at factory. Blades and hubs shall be constructed of anodized aluminum with steel shafts and ball bearings. Condenser fans shall be direct-driven propeller type. Evaporator fans shall be direct-driven or belt-driven double inlet centrifugal fan with forward curved blades.

5. Refrigerant circuits shall have gas and liquid piping, fittings, valves, thermostatic expansion valves, liquid line sight glasses, filters, replaceable core dryer-strainer, liquid charging valve, charging manifold, and pressure gauges.

H. Provide ventilation damper assembly with automatic actuator. Damper shall close automatically on unit shut down and loss of power. Damper shall be open on heating and cooling.

I. Provide disposable type air filter with holding frame of galvanized steel construction. Sizes and capacities shall be as indicated. Air filters shall be UL-approved type tested in accordance with UL 900. Rated average efficiency shall be minimum 45 percent based on ASHRAE 52.1 test method.

J. Controls shall consist of push-button, heat-off-cool selector switch, and adjustable thermostat with upper and lower limits. Additional controls for heat pumps shall include outdoor coil defrost thermostat and adjustable outdoor temperature thermostat.

K. Safeties shall consist of automatic reset over-temperature and over-current protection for compressor, automatic reset over-temperature protection for fan motor; and two over-temperature protectors for electric heating coil.

2.03 SPLIT-TYPE AIR SOURCE HEAT PUMPS

A. Requirements: Provide split type air source heat pumps consisting of indoor units and remote air-to-air outdoor units, rated in accordance with ARI 210/240. Air-Source Heat Pump Equipment Design separate units to be used together, and base ratings on the use of matched assemblies. Provide units complete with air filters, control dampers, base, factory installed internal insulation, controls, wiring, and internal refrigerant piping.

B. Indoor Unit:

1. Indoor unit shall be completely assembled to form an integral unit in which all components are properly matched. Unit shall be located indoor as indicated. Unit shall be capable of both continuous 24-hour per day operation, and intermittent operation.

2. Indoor unit shall consist of cabinet type centrifugal fan section, electric heating coil where indicated, direct expansion cooling coil section, and air filter and mixing box with dampers where indicated. Each section shall be constructed of a galvanized steel frame with removable minimum 18 gage galvanized steel panels. Sections shall be bolted together to make up a single unit. Bolting flanges shall be sealed to prevent leakages. Steel transition pieces or flexible connections shall be provided where shown or required.

3. Access panels shall be provided for each section and both faces of the coils.

4. Inlet and outlet sections of the unit for ducted air delivery shall have flanges or collars for attachment of flexible connections or ducts.

5. Blower shall be double width, double inlet, and centrifugal fan suitable for cabinet type design. Fan section shall consist of one or more fan wheels as required. Fan housing shall be constructed of steel members and plates reinforced for maximum rigidity. Shaft bearings shall be supported independently from the fan section panels. Blower shall be statically and dynamically balanced. Belt drives shall be designed for 50 percent overload capacity and shall be provided with adjustable pulleys. Blower-motor assembly shall be resiliently mounted on spring vibration isolators.

6. Coil section shall consist of a cooling coil and heating coil where indicated. Cooling coils shall be direct expansion type constructed of aluminum fins mechanically bonded to seamless copper tubes. Heating coils shall be electric type as specified herein. Coil sections shall be arranged to allow removal of the coils from either side of the housing, unless otherwise indicated. The coil section shall be provided with a waterproofed and insulated galvanized steel drain pan with drain connection.

7. Indoor unit cabinet shall be insulated with one-inch thick 1.5 pounds per cubic feet density glass fiber insulation. Unit cabinet shall be coated with baked enamel finish.

8. Provide either integral or remote filters, as indicated. Integral filters shall be 2 inches deep low efficiency filters as specified herein. The remote filters shall include 2 inches deep low efficiency filters and high efficiency bag filters in side servicing housing as specified herein.

9. Fan motors shall be premium, highest efficiency, and shall conform to NEMA MG 1. Motor starters shall conform with NEMA ICS 1. Motors shall be totally enclosed fan cooled. Motor starters shall be magnetic across the line type. Floor-mounted indoor unit starters and controls shall be enclosed in NEMA 4X enclosure. Ceiling suspended indoor unit starters and controls shall be enclosed in NEMA 12 general-purpose enclosure. All starter panels shall be furnished with circuit breaker main disconnect switch.

C. Outdoor Unit:

1. Unit and components shall be completely factory assembled, pre-wired, tested, and ready to operate. Unit shall be capable of operating at rated capacity at the specified ambient air temperature and conditions. Equipment shall be suitable for outdoor installation at rooftop or ground level locations as indicated. Unit shall be capable of both continuous operation and intermittent operation.

2. Each unit shall have either one or two completely independent refrigeration circuits as indicated. Where two circuits are indicated for an individual unit, each circuit shall be suitable for load sharing and/or standby duty.

3. Each unit shall be provided with either one or two compressors as required by the specified refrigeration circuits. Compressors shall be reciprocating, serviceable semi-hermetic, or hermetic type with crankcase heater, with entire running gear assembly internally suspended, and externally mounted on resilient rubber mounts. Suction and discharge valves shall have hardened seats. Unit shall have multiple step capacity control, spring-loaded relief valve, and removable heads with unloader timers. Compressor motor shall be provided with heat sensing elements embedded in the motor winding.

4. Condenser coils shall be air-cooled type with minimum 3/8-inch outside diameter seamless copper tubing. Coil shall have aluminum plate fins mechanically bonded to copper tubes.

5. Condenser fans shall be statically and dynamically balanced propeller type, direct driven and discharging upward.

6. Unit cabinet shall be constructed of galvanized steel, bonderized and coated with baked enamel. Cabinet panels shall be removable for service access to all operating components.

7. Unit shall be provided with 4-way reversing valve designed for fail-safe in heating position.

8. Internal refrigerant piping shall be hard-drawn type ACR copper tubing with wrought-copper fittings and brazed joints.

9. Compressor motor shall be premium, highest efficiency, and shall be rated for electric power characteristics as indicated. Motor shall conform to NEMA MG 1. Starters shall conform to NEMA ICS1. Motor shall be constant speed, low starting current and high torque squirrel cage induction type, and shall have a magnetic across the line motor starter.

10. Provide each outdoor unit with unit mounted disconnect switch.

D. Unit Controls:

1. Unit controls shall be housed in a NEMA 4X enclosure for outdoor units and floor mounted indoor units, and NEMA 12 for other indoor units integral with the unit cabinet. The following control devices shall be provided:

   a. Compressor motor magnetic starters.

   b. Condenser fan motor magnetic starters.

   c. Control power transformers.

   d. Reversing valve control.

   e. Occupied/unoccupied program relay.

   f. Override timer.

2. Protective devices shall be designed to control operation under the following conditions:

   a. Motor overload.

   b. Under voltage.

   c. Locked rotor.

   d. Excessive winding temperature.

   e. High and low operating pressures.

   f. Loss of refrigeration.

   g. Compressor rapid cycling.

3. Where two compressors per unit are required, switch for alternating lead compressor timer shall be provided.

2.04 ROOFTOP PACKAGED AIR-CONDITIONING UNITS OR AIR SOURCE HEAT PUMPS

A. Requirements: Units shall be factory-assembled and tested, designed for roof installation, and consisting of compressors, condensers, evaporator coils, condenser and evaporator fans, refrigeration and temperature controls, filters, and dampers. Capacities and electrical characteristics shall be as indicated.

B. Casing: Manufacturer's standard casing construction, having corrosion protection coating, and exterior finish in accordance with Section 20 10 13, Common Materials and Methods for Facility Services – Fire Suppression, Plumbing and HVAC. Casings shall have removable panels or access doors for inspection and access to internal parts, a minimum of 1/2-inch thick thermal insulation, knockouts for electrical and piping connections, power disconnect switch, and an exterior condensate drain connection and lifting lugs.

C. Roof Curbs: Manufacturer's standard construction, 14 inch high minimum, insulated and having corrosion-protective coating, complete with factory-installed wood nailer and drain nipple.

D. Additional Components: Remaining components and features shall be as specified in Article 2.03 herein. Units shall have economizer and return fan as required.

2.05 ROOFTOP PACKAGED AIR-CONDITIONING UNITS

A. General: Provide outdoor, roof mounted self-contained units with direct expansion cooling, gas combustion for heating where indicated, power exhaust fan and controls designed for variable volume, variable temperature operation where indicated and complete control system.

B. Quality Assurance:

1. Unit shall be rated in accordance with ARI Standards 270 and 360 and designed in accordance with UL Standard 1995.
2. Unit shall be designed to conform to ASHRAE 15.
3. Unit shall be ETL=tested and certified in accordance with ANSI Z21.47 Standard as a total package.
4. Roof curb shall be designed to conform to nationally recognized standards.
5. Insulation and adhesive shall meet NFPA 90A requirements for flame spread and smoke generation.
6. Unit casing shall be capable for withstanding Federal test method Standard No. 141 (Method 6061) 500-hour salt spray test.
7. Unit shall conform to ISO 9002 manufacturing quality standard.

C. Description: Self-contained, packaged, factory assembled and pre-wired, consisting of cabinet and frame, supply fan, controls, air filters, refrigerant cooling coil, compressor, condenser coil and condenser fan and gas fired heater, power exhaust and staged heating and cooling with automatic heat/cool change over when heating is specified on drawings. Unit shall be furnished in accordance with the following minimum requirements:

1. Disconnect Switch: Factory mount disconnect switch on equipment.

2. Cabinet: Galvanized steel with baked enamel finish, access doors or removable access panels with quick fasteners locking door handle type with piano hinges. Structural members shall be minimum 19 gage (0.90 mm) with access door or removable panels of minimum 20 gage (0.90 mm).

3. Insulation: One half-inch thick neoprene coated glass fiber with edges protected from erosion. Aluminum foil-faced fiberglass insulation shall be used for the gas heat compartment. Insulation shall be on outside, not in airflow path.

4. Supply Fan: Forward curved centrifugal type, resiliently mounted with V-belt drive, adjustable variable pitch motor pulley, and rubber isolated hinge mounted high efficiency motor. Refer to Section 20 30 13, Vibration Isolation and Seismic Control for Facility Services. Fan and fan motor bearings to be ABMA 9 or 10 L-10 life of 50,000 hours.

5. Air Filters: Two inch thick glass fiber, UL 900 Class I of II, disposable media in metal frames. Filters shall be accessible through an access panel.

6. Roof Mounting Curb: 14 inches (350 mm) high-galvanized steel, channel frame with gaskets, mailer strips.

7. Burner (if applicable)

    a. Gas Burner: Induced draft type burner with adjustable combustion air supply, pressure regulator, gas valves, modulating gas control valve, manual shut-off, intermittent spark or glow coil ignition, flame sensing device, and automatic 100 percent shut-off pilot.

    b. The heat exchanger shall be of the tubular-section type constructed of a minimum of 20-gage steel coated with a minimal 1.2 mil aluminum-silicone alloy for corrosion resistance.

    c. Burners shall be of the ribbon or in-shot type constructed of aluminum-coated steel.

    d. Gas Burner Safety Control: Energize ignition, limit time for establishment of flame, prevent opening of gas valve until heat exchange is purged and pilot flame is proven, stop gas flow on ignition failure, energize induced draft fan, and after air flow proven and slight delay, allow gas valve to open.

    e. High Limit Control: Temperature sensor with fixed stop at maximum permissible setting, de-energize burner on excessive bonnet temperature and energize burner when temperature drops to lower safe value.

f. Induced draft fan shall be of the direct-driven, single inlet, forward-curved, centrifugal type of propeller type. Induced draft fan shall be made from steel with a corrosion-resistant finish and shall be dynamically balanced.

8. Evaporator Coil

   a. Provide copper tube aluminum fin coil assembly with galvanized drain pan sloped to drain connection with pre-piped exterior trap.

   b. Provide capillary tubes or thermostatic expansion valves for units of 6 tons (21 kw) capacity and less, and thermostatic expansion valves and alternate row circuiting for units 7.5 tons (26 kw) cooling capacity and larger.

9. Compressor

   a. Provide highest energy efficiency ratio hermetic or semi-hermetic compressors, 3600 rpm maximum, with positive lubrication, crankcase heater, high and low pressure safety controls, motor overload protection, suction and discharge service valves and gage ports, and filter drier.

   b. Five minute timed off circuit to delay compressor start.

   c. Provide step capacity control by cycling compressors. Provide compressor unloading capability on 15 ton and larger units.

   d. Each compressor shall be mounted on resilient, or spring type for 7.5 ton and larger capacity units, vibration isolators with seismic restraint.

10. Condenser Coil

    a. Provide copper tube aluminum fin coil assembly with subcooling rows and coil guard.

    b. Provide direct driven propeller fans, resiliently mounted with corrosion resistant blades, fan guard, motor overload protection, wired to operate with compressor. Provide highest efficiency fan motors. Motor shall be equipped with variable frequency drives per CEC Title 24.

    c. Provide refrigerant pressure switches to cycle condenser fans.

11. Mixed Air Casing

    a. Galvanized steel with baked enamel finish with damper access doors.

    b. Dampers: provide outside air, return air, and relief dampers, or powered exhaust where indicated, with damper operator and control package to automatically vary outside air quantity from fixed minimum to maximum of 100 percent. Outside air damper shall close completely upon unit shutdown. Relief dampers may be gravity type.

    c. Gaskets: Provide tight fitting dampers with edge gaskets maximum leakage 5 percent at 2 inches pressure differential.

    d. Damper Operator: Less than 50 volt with gear train sealed in oil with spring return on units 7.5 ton cooling capacity and larger.

12. Integrated Economizer

    a. Integrated type capable of simultaneous economizer and compressor operation to provide cooling with outdoor air.

    b. Equipped with low-leakage dampers not to exceed three percent leakage, at 1.0 in. water gauge pressure differential.

    c. Capable of introducing up to 100 percent outdoor air.

    d. Equipped with dry-bulb temperature control to govern economizer changeover.

    e. Package shall include an exhaust fan, motor, and damper for vertical flow units connected to economizer controller where indicated; otherwise provide, as a minimum, relief dampers to control over pressurization of building.

13. Operating Controls

    a. Provide low voltage, programmable room thermostat with a digital display to control compressor and condenser fan, and supply fan to maintain temperature setting.

        1) Include system selector switch off-heat-auto-cool and fan control switch (auto-on).

        2) Provide single acting thermostat with minimum 2 stage cooling.

        3) Locate thermostat in room as shown.

        4) Provide fan time delay to prevent cold air delivery.

14. Safety Controls

    a. Unit shall incorporate a solid-state compressor lockout, that provides reset capability at the space thermostat, should any of the following safety devices trip and shut off compressor:

        1) Compressor over-temperature, over-current.

        2) Low-pressure switch.

        3) Freezestat (evaporator coil).

        4) High-pressure switch.

    b. Heating section shall be provided with the following minimum protection:

        1) High-temperature limit switch.

        2) Induced-draft pressure switch.

        3) Flame rollout switch (manual reset).

        4) Flame proving controls.

        5) Redundant gas valve(s).

15. Operating Controls – Single Zone Units

    a. Electric solid-state microcomputer based room thermostat located as indicated.

    b. Room thermostat shall incorporate:

        1) Automatic switching from heating to cooling.

    c. Room thermostat display shall include:

    d. Time of day.

        1) Actual room temperature.

        2) Programmed temperature.

        3) System model indication: Heating, cooling, auto, off, fan auto, fan on.

        4) Stage heating or cooling operation.

16. Operating Controls – Variable Volume Units

    a. Temperature sensing element located in return air shall signal electronic logic panel to control mixing dampers and cooling in sequence. Mixing section shall operate as first stage of cooling and revert to minimum outside air above approximately 75 degrees Fahrenheit (24 degrees Celsius) as determined by temperature of return and outdoor air.

    b. Temperature sensing elements located in return air shall control cooling by cycling compressors, cylinder unloading, and hot gas reheat.

    c. Control logic shall allow supply air reset under low load or airflow conditions.

    d. Seven day time clock with spring carry over or electronic clock with battery backup shall control unit on occupied/un-occupied schedule. At night, unit shall be off. Locate clock in remote control panel with status lights.

17. Head Pressure Control Package: A solid-state control with condenser coil temperature sensor for controlling condenser-fan motor speed to maintain condensing temperature between 90 Fahrenheit and 100 Fahrenheit at low outdoor ambient temperature shall be provided on 7.5 ton and larger units.

2.06 SPLIT SYSTEM AIR CONDITIONING UNITS

A. General: Provide air handling units and remote air cooled condensing units that form a complete, fully compatible and operable system, rated in accordance with ARI 240.

B. Description:

1. Air Handling Units: shall be furnished complete, including, but not limited to casing, supply fan, direct expansion coil, mixing box, filter section, and controls all factory assembled and pre-wired and shall meet following requirements:

    a. Casing: Sectional Type of galvanized steel with removable galvanized steel access panels provide access to: a) both faces of evaporator coil(s), b) filters,

c) mixing dampers, d) fan motor, e) Fan and f) controls. Exterior of casing shall be finished with enamel coating. Interior of casing shall be insulated as specified in Section 20 10 13. Provide galvanized steel condensate pan sloped to draining drain connection and pre-piped trap.

b. Insulation: Neoprene coated, glass fiber, applied to internal surfaces with adhesive and weld pins with exposed edges of insulation coated with adhesive.

1) "K" value at 75 degrees Fahrenheit. Maximum 0.26 Btuh/inch/sq ft/degrees Fahrenheit.

2) Density: 1 inch thick, 1-1/2 lbs/cu ft.

C. Fans

1. Type: Forward curved, double width, double inlet, and centrifugal type fan.

2. Performance Ratings: Conform to AMCA 210 and label with AMCA Certified Rating Seal.

3. Sound Ratings: AMCA 301; tested to AMCA 300 and label with AMCA Certified Sound Rating Seal.

4. Bearings: Self-aligning, grease lubricated, ball or roller bearings with lubrication fittings extended to exterior of casing with aluminum tube and grease fitting rigidly attached to casing.

5. Mounting: Locate fan and motor internally mounted on weld steel base coated with corrosion resistant paint and attached to casing using resilient vibration isolators. Factory mount motor on slide rails. Provide access to motor, drive, and bearing through removable casing panels or hinged access doors.

6. Flexible Connection shall separate fan and coil, and adjacent sections.

D. Bearings and Drives

1. Bearings: Heavy-duty pillow block type, self-aligning, grease- lubricated ball bearings, with ABMA 9 (L-10 life at 50,000 hours).

2. Shafts: solid, hot rolled steel, ground and polished, with Key-way, and protectively coated with lubricating oil.

3. V-Belt Drive: Coat iron or steel sheaves, dynamically balanced, bored to fit shafts, and keyed. Variable and adjustable pitch sheaves for motors 15 hp and under selected so required rpm is obtained with sheaves set at mid-position; fixed sheave for 20 hp and over, matched belts, and drive rated as recommended by manufacturer of minimum 1.5 times nameplate rating of the motor.

4. Belt Guard: Fabricate to SMACNA Standard; 0.106 inch (2.6 mm) thick, 3/4 inch (20 mm) diamond mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation, with provision for adjustment of belt tension, and use of tachometer with guard in place.

E. Coils

1. Casing: Provide access to both sides of coils. Enclose coils with headers and return bends exposed outside casing. Slide coils into casing through removable end panel.

2. Eliminators: Three break of galvanized steel, mounted over drain pan.

3. Fabrication:

   a. Tubes: 5/8-inch (16 mm) OD seamless copper expanded into fins, brazed joints.

   b. Fins: Aluminum.

   c. Casing: Die formed channel frame of galvanized steel.

   d. Headers: Seamless copper tubes with silver brazed joints.

   e. Liquid Distributors: Brass or copper venturi distributor with seamless copper distributor tubes.

   f. Configuration: Down feed with bottom suction.

F. Filters

1. Filter Box: Section with filter guides, access doors from both sides, for side loading with gaskets and blank-off plates.

2. Filter Media: UL 900 listed, Class I or Class II, approved by Engineer.

3. Flat 2 inches (50 mm) disposable panel filters.

G. Dampers

1. Mixing Boxes: Galvanized steel section with exterior enamel coated and factory mounted outside and return air dampers of galvanized steel with vinyl bulb edging and edge deals mounted in galvanized frame, with galvanized steel axles in self-lubricating nylon bearings, in parallel blade arrangement.

2. Damper Leakage: Maximum 2 percent at 4 inch wg (1 kPa) differential pressure when sized for 2000 fpm (10 m/s) face velocity.

3. Air Cooled Condensing Units: Self-contained, packaged, factory assembled and pre-wired units suitable for outdoor use consisting of cabinet, compressors, condensing coil and fans, integral sub-cooling coil, controls, liquid receiver, and screens.

a. Construction and Ratings: In accordance with ARI 210/240. Testing shall be in accordance with ASHRAE 14.

b. Performance Ratings: Energy Efficiency Rating (EER) and Coefficient of Performance (COP) not less than prescribed by ASHRAE 90A.

c. Casing

   1) House components in galvanized steel panels with weather resistant, baked enamel finish.

   2) Mount starters, disconnects, and controls in NEMA 4 OR 4XR weatherproof panel provided with full opening access doors. Provide mechanical interlock to disconnect power when door is opened.

   3) Provide removable access doors or panels with quick fasteners and piano hinges.

d. Roof Curbs: Manufacturer's standard construction, or shop fabricated 18 gage minimum, 14 inch high minimum, insulated and having corrosive protective coating, complete with factory-installed wood nailer and drain nipple.

e. Condenser Coils

   1) Coils: Aluminum fins mechanically bonded to seamless copper tubing. Provide sub-cooling circuits. Air test under water to 425 pig (2900 kPa), and vacuum dehydrate.

   2) Coil Guard: Expanded Metal.

f. Fans and Motors

   1) Vertical discharge direct driven propeller type condenser fans with fan guard on discharge. Equip with roller or ball bearings with grease fittings extended to outside of casing.

   2) Weatherproof, highest efficiency motors suitable for outdoor use, single phase permanent split capacitor or 3 phase, with permanent lubricated ball bearings and built in current and thermal overload protection.

g. Compressors

   1) Compressor: Semi-hermetic reciprocating type of Hermetic reciprocating type.

   2) Mounting: Statically and dynamically balance rotating parts and mount on spring vibration isolators. Internally isolate hermetic units on springs.

   3) Lubricating System: Reversible, positive, displacement oil pump with oil charging valve, oil level sight glass, and magnetic plug or strainer.

   4) Motor: Constant speed 1800 rpm suction gas cooled with electronic sensor and winding over temperature protection, designed for across-the-line starting. Furnish with starter.

   5) Capacity Reduction Equipment: Suction valve unloaders, with lifting mechanism operated by electrically actuated solenoid valve, with onloaded compressor start; controlled from suction pressure.

6) Sump Oil heater: Evaporates refrigerant returning to sump during shut down. Energize heater continuously.

h. Refrigerant Circuit

1) Provide each unit with one refrigerant circuit, factory supplied and piped.

2) For each refrigerant circuit, provide:

a) Filter dryer replaceable core type.

b) Liquid line sight glass and moisture indicator.

c) Thermal expansion valve for maximum operating pressure.

d) Insulated suction line.

e) Suction and liquid line service valves and gage ports.

f) Liquid line solenoid valve.

g) Charging valve.

h) Discharge line check valve.

i) Compressor discharge service valve.

j) Condenser pressure relief valve.

H. Controls

1. On unit, mount weatherproof steel control panel, NEMA 250, containing power and control wiring, molded case disconnect switch, factory wired with single point power connection. Factory mount disconnect switch on unit.

2. For each compressor, provide across-the-line starter, non-recycling compressor overload, starter relay, and control power transformer or terminal for controls power. Provide manual reset current overload protection. For each condenser fan, provide across-the-line starter with starter relay.

3. Provide safety controls arranged so any one will shut down machine:

a. High discharge pressure switch manual reset for each compressor.

b. Low suction pressure switch automatic reset for each compressor.

c. Oil Pressure switch (manual reset).

4. Provide the following operating controls:

a. Thermostat located in room cycles compressors, activates cylinder unloaders and activates solenoid valves in refrigerant circuit.

5. Provide controls to permit operation down to 0.5 percent ambient temperature of the current CCR Title 24 conditions.

a. Thermostat to cycle fan motors in response to outdoor ambient temperature.

2.07 HEATING AND VENTILATING UNITS

A. General: Provide outdoor roof mounted horizontal or indoor vertical heating and ventilating units as indicated that are packaged by a manufacturer in a modular form. The units shall be constructed with heating coils, mixing boxes, combination filter/mixing box section, filter section, and fan section.

B. Casing

1. Construction: Fabricate on channel base and drain pan of weld steel. Assemble sections with gaskets and bolts. Casing shall be galvanized steel, with outside finish and shall be Manufacturers standard paint on exterior. Floor Plate shall be galvanized steel, 1.382 inch (3.5 mm) thick.

2. Insulation: Neoprene coated, glass fiber, applied to internal surfaces with adhesive and weld pins with exposed edges of insulation coated with adhesive.

   a. “K” (Ksi value at 75 degrees Fahrenheit (42 degrees Celsius): maximum 0.26 Btuh/inch/sq ft/degrees Fahrenheit (0.037 W/m/Degree K).

   b. Density: 1 inch (25 mm) thick, 1-1/2 lbs/cu ft (24 kg/cu m).

3. Access Doors: Of sufficient quantity and size to provide full access to both sides of coil filters and dampers and shall be of galvanized steel construction designed for flush mounting, with gasket, latch, and handle assembly.

C. Roof Curbs for roof mounted units: Manufacturer’s standard construction or shop fabricated 18 gage minimum, 14 inch high minimum, insulated and having corrosive protective coating, complete with factory-installed wood mailer and drain nipple.

D. Fans

1. Type: Forward curved, double width, double inlet, centrifugal type fan.

2. Performance Ratings: Conform to AMCA 210 and label with AMCA Certified Rating Seal.

3. Sound Ratings: AMCA 301; tested to AMCA 300 and label with AMCA Certified Sound Rating Seal.

4. Bearings: Self-aligning, grease lubricated, ball or roller bearings with lubrication fittings extended to exterior of casing with aluminum tube and grease fitting rigidly attached to casing.

5. Mounting: Provide access to motor, drive, and bearing through removable casing panels or hinged access doors. Mount base on vibration isolators.

E. Bearings and Drives

1. Bearings: Heavy-duty pillow block type, self-aligning, grease-lubricated ball or roller bearings, with ABMA 9 or 10 (L-10 life at 50,000 hours).

2. Shafts: Solid, hot rolled steel, ground and polished, with key-way, and protectively coated with lubricating oil.

3. V-Belt Drive: Cast iron or steel sheaves, dynamically balanced, bored to fit shafts, and keyed. Variable and adjustable pitch sheaves for motors 15 hp and under selected so required rpm is obtained with sheaves set at mid-position; fixed sheave for 20 hp and over, matched belts, and drive rated as recommended by manufacturer or minimum 1.5 items nameplate rating of the motor.

4. Guard: Fabricated to SMACNA Standard; 0.106 inch (2.6 mm) thick, 3/4 inch (20 mm) diamond mesh wire screen weld to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short-circuiting vibration isolation. with provision for adjustment of belt tension, lubrication, and use of tachometer with guard in place.

F. Coils

1. Casing: Provide access to both sides of coils. Enclose coils with headers and return bends exposed outside fully contained within casing. Slide coils into casing through removable end panel with blank off sheets and sealing collars at connection penetrations.

2. Drain Pans: 24 inch (600 mm) downstream of coil.

3. Eliminators: Three break of galvanized steel mounted over drain pan.

4. Air Coils: Certify capacities, pressure drops and selection procedures in accordance with ARI 410.

5. Fabrication:

   a. Tubes: 5/8 inch (16 mm) OD seamless copper expanded into fins, brazed joints.

   b. Fins: Aluminum.

   c. Casing: Die formed channel frame of galvanized steel.

6. Water Heating Coils:

   a. Headers: Cast iron, seamless copper tube, or prime coated steel pipe with brazed joints.

   b. Configuration: Drainable, with threaded plugs for drain and vent; serpentine type with return bends on smaller sizes and return headers on lager sizes. Furnished with automatic vent valve.

G. Filters

1. Filter Box: Section with filter guides, access doors from both sides, for side loading with gaskets and blank-off plates.

2. Filter Media: UL 900 listed, Class l or Class ll, approved by Engineering.

3. Flat 2 inches (50 mm) deep disposable panel filters.

H. Dampers (if applicable)

1. Mixing Boxes: Galvanized steel section with exterior factory mounted outside and return air dampers of galvanized steel with vinyl bulb edging mounted in galvanized frame, with galvanized steel axles in self-lubricating nylon bearings, in parallel blade arrangement with damper blades positioned across short air opening dimension.

2. Damper leakage: Maximum 2 percent at 4 inch wg (1 kPa) differential pressure when sized for 2000 fpm (10 m/s) face velocity.

2.08 HOT WATER BOILERS

A. General: Furnish and install factory assembled, factory fire-tested, self contained, readily transported steel membrane wall water tube boiler ready for automatic operation except for connection of water, fuel, electrical, and vent services. The hot water boiler shall be mounted on integral structural steel frame base with integral forced draft burner, burner control, boiler trim, refractory, insulation, and jacket. Unit shall conform to ASME BPVC SECIV and SECVIII and AGA Z21.13 and UL726 for construction of boilers and be AGA certified.

B. Boiler Shell:

1. Construct boiler to applicable ASME Boiler and Pressure Vessels Code for allowable working pressure of 30 psi water.

2. Provide two lifting eyes on tip of boiler.

3. Provide adequate tappings, observation ports, removable panels and access doors for entry, cleaning, and inspection. Removable access panels(s) to burner and separate removable access panels to water tubes shall each be full width and height designed to provide unobstructed access to burner and water tubes.

4. Insulate casing with 1-1/2 inch minimum thick glass fiber blanket insulation covered by sectional galvanized or zinc coated steel sheet metal jacket. Water tube access panel and chamber shall be insulated with high temperature insulation board permanently attached to panel and casing.

5. Factory paint boiler, base, and other components with hard finish enamel.

C. Hot Water Boiler Trim:

1. Provide Low Water Cut-off with drain valve and manual reset to automatically prevent burner operation whenever boiler water falls below safe level.

2. Provide complete automatic reset type temperature controls that shall, as a minimum

   a. Control burner on/off to maintain temperature and

   b. Control burner firing rate to maintain temperature.

   A manual reset type temperature control shall also be provided to control the burner to prevent boiler water temperature from exceeding safe system water temperature.

3. Provide pressure control of fixed setting type to control burner to ensure minimum operating pressure.

4. Provide a blend pump installed between supply and return connections designed to ensure minimum continuous circulation through the hot water boiler.

5. Provide ASME rated pressure relief valves, piped to drain.

6. Provide combination pressure and thermometer gage.

D. Fuel Burning System:

1. Provide forced draft automatic burner designed to burn natural gas at 1050 Btu/cubic foot and 7 inches water gage inlet pressure and maintain fuel-air ratios automatically.

2. Blower shall be statically and dynamically balanced, have adequate capacity to supply combustion air to burner and be directly connected to motor.

3. Single motor shall control combustion air damper and fuel valves.

4. Gas burner shall be forced draft, high radiant multiport power burner with electric ignition and modulating main valves with low fire ignition position.

5. Natural gas burner piping shall be factory installed and shall be complete gas train including high and low gas pressure switches, plug valve, gas pressure regulator, pilot valve and modulating main valve.

E. Controls

1. Mount NEMA 250, Type 1 hinged metal panel on boiler, containing electronic combustion control, blower motor starter, low fire hold time, automatic-manual firing selection switch, and control switches.

2. Provide electronic combustion control-to-control ignition, starting and stopping of burner, and both pre-combustion purge and post combustion purge. Burner to shut down in event of ignition, pilot, or main flame failure. Interlock to shut down burner upon combustion air pressure drop.

3. Provide electronic detector to prevent primary fuel valves from opening until pilot flame is established.

F. Performance

1. Performance rating shall be in accordance with HI – Testing and Rating Standard for Cast Iron and Steel Heating Boilers.

2. Minimum Efficiency shall be 80 percent from 30 to 100 percent of full load firing rate. Efficiency and capacity shall be certified by factory. In addition to factory certified capacity and efficiency tests, the boilers shall be performance tested by the factory to check construction, controls, and operation or unit. Submit copies of inspection report to Engineer prior to shipment.

2.09 RECIRCULATION PUMPS

A. General: Provide centrifugal pumps and related accessories normally encountered in hydronics system.

1. In-Line Circulators

a. Type: Horizontal shaft, single stage, direct connected with resiliently mounted motor for in-line mounting, oil lubricated, for 125 psig (860 kPa) maximum working pressure.

b. Casing: Cast iron, with flanged pump connections.

c. Impeller: Cadmium plated steel, keyed to shaft.

d. Bearings: Two, oil lubricated bronze sleeves.

e. Shaft: Alloy or stainless steel with copper or bronze sleeve, integral thrust collar.

f. Seal Carbon rotating against a stationary ceramic seat, 225 degrees Fahrenheit (107 degree Celsius) maximum continuous operating temperature.

g. Drive: Flexible coupling.

h. Electrical Characteristics:

i. Motor: 1750 rpm unless indicated otherwise.

j. Wiring Terminations: Provide terminal tugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70.

2. Base Mounted Pumps

a. Type: Horizontal shaft, single stage, direct connected, radially or horizontally split casing, for 125 psig (860 kPa) maximum working pressure.

b. Casing: Cast iron, with suction and discharge gage ports, renewable bronze casing wearing rings, seal flush connection, drain plug, flanged suction and discharge.

c. Impeller: Bronze, fully enclosed, keyed to shaft.

d. Bearings: Oil lubricated roller or ball bearings.

e. Shaft: Alloy steel with copper, bronze, or stainless steel shaft sleeve.

f. Seal: Carbon rotating against a stationary ceramic seat, 225 degrees Fahrenheit (107 degrees Celsius) maximum continuous operating temperature.

g. Drive: Flexible coupling with coupling guard.

h. Baseplate: Cast iron or fabricated steel with integral drain rim.

i. Electrical Characteristics:

j. Motor: 1750 rpm unless specified otherwise.

k. Wiring Terminations: Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70.

3. Preparation

a. Verify that electric power is available and or the correct characteristics.

2.10 AIR COILS

A. General: Provide heat transfer coils for installation in air systems, where indicated in heating, ventilation, air conditioning units, ductwork, and variable air volume units. Equipment shall be capable of both continuous operation and intermittent operation. Insulate headers located outside air flow as specified for piping.

B. Refrigerant Coils

1. Tubes: 5/8 inch (16 mm) OD seamless copper arranged in parallel or staggered pattern, expand into fins, silver brazed joints.

2. Fins: Aluminum continuous plate type with full fin collars.

3. Casing: Die formed channel frame of 16 gage (1.6 mm) galvanized steel with 3/8 inch (9.5 mm) mounting holes on 3 inch (75 mm) centers. Provide tube supports for coils longer than 36 inches (900 mm).

4. Headers: Seamless copper tubes with silver brazed joints.

5. Liquid Distributors: Brass or copper venturi type distributor with seamless copper distributor tubes. Maximum 12 circuits per distributor.

6. Testing: air test under water at 300 psig (2070 KPa) for working pressure of 250 psig (1720 KPa); clean, dehydrate, and seal with dry nitrogen charge.

7. Configuration: Down feed with bottom suction to prevent trapping of oil.

8. Fin Spacing: 8 fins per inch (3.1 mm on center).

9. Provide sight glass in liquid line within 12 inches (300 mm) of coil.

C. Hydronic Coils:

1. Hydronic Coils: Connect water supply to leaving air side of coil counterflow arrangement.

2. Provide shut-off valve on supply line and lockshield balancing valve on return line.

3. Locate water supply at bottom of supply header and return water connection at top.

4. Provide float operated automatic air vents at high points complete with stop valve.

5. Ensure water coils are drainable and provide drain connection at low points.

6. Provide three break moisture eliminators of 24 gage (0.7 mm) galvanized steel, where air velocity exceeds 500 ft/min (2.5 m/sec).

7. Provide drain pan and drain connection; fabricate from 20 gage (1.0 mm) galvanized steel, extend 3 inches (75 mm) from face of entering air side, 6 inches (150 mm) from face of leaving air side and 4 inches (100 mm) from face of eliminators. Condensate in drain pan after condensate drain trap shall flow through flexible plastic hose to nearest floor drain.

D. Electric Heating Coils

1. Electric heating coils shall be provided, where indicated, in ductwork, air handling units, and variable air volume units. Equipment shall be capable of both continuous operation and intermittent operation. Duct mounted heating coils shall be flanged type.

2. Electric heating coils and controls shall be UL listed and shall meet the requirements of the California Electrical Code and NFPA 70 grounding lugs shall be provided. Internal wiring, including step controllers and overcurrent protection of resistance steps, shall be factory installed and terminated at terminal blocks. Heater power and control terminals shall be marked.

3. Elements shall be open coil type. Wire element shall consist of 80 percent nickel and 20 percent chromium alloy. Supports for elements shall be ceramic bushings, spaced not more than 3.5 inches on centers.

4. Enclosure for heaters shall conform with NEMA 1. Insulation constructed of minimum 5/16-inch thick glass fiber shall be provided between the mounting and the terminal box.

5. Internal safety controls shall be serviceable through the terminal box without removing the heater from the duct or air handling unit, and shall be provided complete with the following:

    a. Integral thermal cutout temperature sensing elements;

b. Automatic-reset thermal cutout temperature sensing elements;

c. Switch to de-energize circuits in the terminal box, when the terminal box is opened;

d. Air flow sensing device and switch;

e. Energizing the heaters in steps in response to signals step controller circuits;

f. Transformer to provide control circuit power for safety and backup contactors;

g. Disconnecting switch with door interlock; and

h. Disconnecting safety and backup contactors.

2.11 ELECTRIC CABINET CONVECTOR

A. Provide electrical cabinet convector with voltage, phase, capacity, inlet and outlet locations, and size as indicated, UL-labeled. Provide self contained, factory-assembled unit consisting of heating elements, casings having inlet and outlet grilles, air flow baffles, controls, and protective devices.

B. Provide minimum 18 gage steel cabinet with removable front not less than 16 gage and back not less than 18 gage. Convectors shall be for wall mounting installed with bottom six inches above the finished floor. Complete cabinet with inlet and outlet grilles and access to control components. Provide enclosure with factory baked-enamel finish. Color of finish will be selected by the Engineer from manufacturer's standards.

C. Provide heating elements consisting of nickel chromium heating wire embedded in magnesium oxide insulating refractory and sealed in corrosion resistant metallic sheath having fins. Seal and enclose ends of elements in terminal box and press element sheath mechanically after filling to ensure maximum magnesium oxide compaction. Provide steel sheath and fins with copper plating, high temperature ceramic coating or high temperature aluminized finish. Fins shall be spaced a maximum of six per inch. Heat transfer between sheath and fins shall be uniform. Free elements from expansion noise and 60 Hz hum.

D. Provide automatic reset thermal overheat line voltage protection with convector heater to protect from overheating.

E. Provide heaters with factory installed safety disconnect switch or circuit breaker.

F. Provide heater with a built in, tamper resistant thermostat that is tool adjustable without requiring removal of cabinet parts.

2.12 ELECTRIC BASEBOARD HEATERS

A. Requirements: Provide electric baseboard heaters with voltage, phase, and capacity as indicated, UL-labeled. Furnish and install heaters complete with heating elements, brackets and closures, splice plates, interior and exterior corners, controls, and accessible wiring compartment.

B. Cabinet:

1. Provide minimum 18 gage steel cabinet at front and 20 gage at back, and reinforce and support rigidly. Provide cabinet with no sharp or rough edges, forming a strong rigid cover. Provide heavy gage gusset plates for stiffening the enclosure to maintain uniform shape. Cabinet shall have top flat outlet.

2. Front shall be removable. End plates and corner pieces shall be die formed with round edges, fit flush with cabinet surface, and neat in appearance. Provide cabinet with factory baked-enamel finish. Color of finish will be selected by the Engineer from manufacturer's standards.

C. Heating Element: Provide heating element consisting of nickel chromium heating wire embedded in magnesium-oxide insulating refractory and sealed in corrosion resistant metallic sheath with fins. Seal and enclose ends of elements in terminal box and press element sheath mechanically after filling to ensure maximum magnesium oxide compaction. Provide steel sheath and fins with copper plating, high temperature ceramic coating or high temperature aluminized finish. Fins shall be spaced a maximum of six per inch. Heat transfer between sheath and fins shall be uniform. Elements shall be free from expansion noise and 60 Hz hum.

D. Limit Control: Provide continuous end to end automatic reset thermal overheat line-voltage protection with each individual baseboard heater.

E. Disconnect Means: Provide heater with either a factory installed safety disconnect switch or circuit breaker installed in the housing or in an auxiliary matching control section.

F. Thermostat: Provide heater with a built-in, adjustable, tamper-resistant thermostat, that shall be tool-adjustable without requiring removal of cabinet parts. Provide thermostat with an approximate range from 55 degrees Fahrenheit to 85 degrees Fahrenheit, and an operating differential of 3 degrees Fahrenheit or less.

2.13 ELECTRIC UNIT HEATER

A. Requirements: Provide electric unit heater with voltage, phase, capacity, number of steps, and mounting height as indicated. Units shall be UL-labeled. Provide unit heater with terminals for control circuits and for single source of power supply. Provide factory installed control transformer.

B. Housing: Housing shall be not less than 18 gage steel. Housing shall be either galvanized, or bonderized and prime painted, and factory-finished with baked enamel. Brace parts rigidly with heavy steel plates or structural steel shapes to prevent vibration and to maintain alignment. Housing shall be designed to provide ready access to interior parts without unfastening housing from mounting bracket. Furnish swivel-mounting brackets with each heater for wall and/or ceiling mounting where indicated.

C. Heating Element: Provide heating element consisting of nickel chromium heating wire embedded in magnesium-oxide insulating refractory and sealed in corrosion resistant metallic sheath with fins. Seal and enclose ends of elements in terminal

box and press element sheath mechanically after filling to ensure maximum magnesium oxide compaction. Provide steel sheath and fins with copper plating, high temperature ceramic coating or high temperature aluminized finish. Fins shall be spaced a maximum of six per inch. Heat transfer between sheath and fins shall be uniform. Elements shall be free from expansion noise and 60 Hz hum.

D. Louvers: Provide horizontal air discharge units with individually adjustable horizontal louvers. Provide a heavy duty removable, galvanized steel louvered back, heavy grilled, or chrome plated steel wire guard for inlet air. Provide vertical air discharge units with individually adjustable louvers so that air flow pattern can be adjusted in all directions.

E. Fans and Motors: Provide propeller type fans directly connected to fan motor, dynamically balanced, resiliently mounted to the housing, and designed specifically for unit heater application and low noise level. Provide totally enclosed fan motor, continuous duty with built in automatic reset thermal overload protection.

F. Limit Controls: Provide thermal overheat protection located to protect against overheating of unit from any cause.

G. Contactor: Provide unit with factory installed magnetic contactor for remote thermostatic operation, that disconnects all ungrounded contactors to the heater. Provide a control transformer to supply 120 V thermostat control power.

2.14 HOT WATER UNIT HEATER

A. General: Provide hot water unit heaters as indicated.

1. Coils: Seamless copper tubing, silver brazed to steel headers, and with evenly spaced aluminum fins mechanically bonded to tubing.

2. Casing: 18 gage (1.2) steel with threaded pipe connections for hanger rods.

3. Finish: Factory applied baked primer coat as suggested.

4. Fan: Direct drive propeller type, statically and dynamically balanced, with fan guard; horizontal models with permanently lubricated sleeve gearings; vertical models with grease-lubricated ball bearings.

5. Air Outlet: Adjustable pattern diffuser on projection model and four way louvers on horizontal throw models.

6. Motor: Permanently lubricated sleeve bearings on horizontal models, grease lubricated ball bearings on vertical models.

7. Control: Local multi-speed disconnect switch.

8. Capacity: As scheduled, based on 60 degree Fahrenheit (18 degree Celsius) entering air temperature.

2.15 GAS FIRED UNIT HEATER

A. Requirements: Provide gas fired unit heaters as indicated.

1. Units: Self-contained, packaged, factory assembled, pre-wired unit consisting of cabinet, supply fan, burner, controls, and accessories:

    a. Heating: Natural gas fired.

    b. Discharge Louver: Individually adjustable horizontal louvers to match cabinet finish.

    c. Downtown Nozzle: 30 degree nozzle to match outlet and cabinet finish.

2. Cabinet: Galvanized steel with baked enamel finish, easily removed and secured access doors, glass fiber insulation and reflective liner.

3. Supply Fan: Propeller type with direct drive.

4. Gas Burner:

    a. Atmospheric type with adjustable combustion air supply.

    b. Gas Valve: Provide 100 percent safety gas shut-off, 24 volt combining pressure regulation, safety pilot, manual set on-off, pilot filtration, automatic electric valve.

    c. Electronic pilot ignition: With electric spark igniter.

    d. Combustion air damper: With synchronous spring return damper motor.

    e. Non-corrosive combustion air blower with permanently lubricated motor.

5. Gas Burner Safety Control:

6. Thermocouple Sensor: Prevents opening of gas valve until pilot flame is prove and stops gas flow on ignition failure.

7. Flame Rollout Switch: Installed on burner box and prevents operation.

8. Vent Safety Shutoff Sensor: Temperature sensor installed on draft hood and prevents operation, manual reset.

9. Limit Control: Fixed stop at maximum permissible setting, de-energizes burner on excessive bonnet temperature, automatic resets.

B. Operation Controls:

C. Room Thermostat: Cycles burner to maintain room temperature setting.

D. Supply Fan Control: Energized from bonnet temperature independent of burner controls, with adjustable time delay and fixed time on delay, with manual switch for continuous fan operation.

2.16 INFRA-RED TUBE HEATERS

A. Heater Parameters:

1. Two stage infra-red tube heaters shall be RE-VERBER-RAY HL SERIES, as manufactured by Detroit Radiant Products Company, Warren, MI 48089; Reznor Inrea-Rez Model TR/TR-H, Mercer, PA 16137; or equal.

2. Two stage infrared tube heaters shall be Design Certified by the American Gas Association (AGA) and comply with current Occupational Safety and Health Act (OSHA) Requirements.

3. The Contractor shall provide a manufacturer's published warranty covering the heater's stainless steel burner for a period of 10 years, combustion and radiant emitter tube assembly for a period of 5 years, and all components utilized in the heater control assembly for a period of 1 year.

4. Two stage infra-red tube heaters shall be designed to operate when burning natural gas having a heat value of 100 MBH/75 MBH per cubic foot.

B. Two Stage Infra-red Tube Heater Burner Controls:

1. The two-stage infra-red tube heater shall be AGA Design Certified to operate at an input differential of at least 30 percent between the low-fire and high fire modes.

2. Heaters shall equip with a direct silicon carbide ignition system. Power supplied to each burner shall be 120 VAC, 60Hz, and single phase.

3. Heater controls shall include two safety differential pressure switches.

4. Heater control assembly shall include staging indicator lights that define the units operation input ranges.

5. The heater controls shall provide a 60 second post purge as an integral part of the control assembly.

C. Two stage Infra-red Tube Heater Construction:

1. Heater's control housing shall be totally enclosed with an enameled steel exterior.

2. The main burner assembly shall be constructed of stainless steel.

3. Heater's combustion chamber shall be 4 inch O.D. 16 gage titanium alloy or aluminized steel finished with a high emissivity rated, corrosion resistant, black coating.

4. Heater's radiant emitter tube shall be 4 inch O.D. 16 gage aluminized steel finished with a high emissivity rated, corrosion resistant, black coating.

5. The heater's combustion chamber and radiant emitter tube shall incorporate a 4 inch slip fit connection held by a bolted clamp.

6. The silicon carbide igniter shall be readily accessible and serviceable without the use of tools.

7. Reflectors shall be of 0.025 polished aluminum with reflector end caps. Reflectors shall be rotatable from 0 to 45 degrees when required.

8. The heaters shall utilize a downstream turbulator baffle for thermal efficiency.

9. The two stage infrared tube heaters shall be designed such that, at the District's option, outside combustion air may be supplied, an air intake collar shall be supplied.

2.17 INFRA-RED HI INTENSITY HEATERS

A. Heater Parameters:

1. High intensity heaters shall be RE-VERBER-RAY DR SERIES, as manufactured by Detroit Radiant Products Company, Warren, MI 48089; Reznor Infra-Rez Model RIH/RIHV, Mercer, PA 16137; or equal.

2. High intensity heaters shall be Design Certified by the American Gas Association (AGA), approved by Underwriter's Laboratories, Inc. (UL), and shall comply with current Occupational Safety and Health Act (OSHA) Requirements, and accepted by Factory Insurance Association (FIA) and Mutual Fire Insurance Companies (FM).

3. The Contractor shall provide a manufacturer's published warranty covering the heater's ceramic burner for a period 10 years and all the components utilized in the heater control assembly for a period of 1 year.

4. High intensity heaters shall be designed to operate when burning natural gas having a heat value of 50 MBH per cubic foot.

B. High Intensity Infrared Heater Burner Controls:

1. High intensity heaters shall be AGA Design Certified to operate at the designed input rating of 50 MBH per cubic foot.

2. Heaters shall be equipped with a Spark Pilot Ignition System (NSPI-8) with automatic (re) ignition via solid-state spark ignition. Loss of gas shall cause shut-off of main burners and loss of power shall cause 100 percent shut-off of main burners and pilot burners. Power supplied to each burner shall be 120 VAC, 60 HZ, single phase or 24 VAC with a transformer for a sufficient VA rating.

C. High Intensity Infrared Heater Construction:

1. The heater reflector housing and plenum chamber shall be constructed of bright polished aluminum.

2. The Venturi shall be constructed of stainless/aluminized steel.

3. The rods shall be constructed of high temperature stainless steel alloy with ceramic infrared generators.

4. Parabolic reflectors shall be used when units are installed in high mounting applications or to direct the infrared rays in a more focused pattern.

5. Protective screens shall be used in facilities where debris may damage the heater.

2.18 ROOFTOP INDIRECT EVAPORATIVE AIR COOLER

A. General Description: Units shall be factory-assembled and tested designed for roof installation and connecting of gas-fired furnace section, blower section, indirect evaporative cooling section, filter, damper and temperature controls. Capacities and electrical characteristics shall be as indicated on the Contract Drawings.

B. Casing: All side and roof panels shall utilize standing seam modular panel construction and shall be assembled with bolts such that they are removable. Casing shall be of not less than 16 gage galvanized, painting grip steel sheets reinforced as required with structural steel to provide structural integrity and prevent breathing drumming.

C. Access doors: Provide hinged, double-wall, insulated man-size access doors for regular maintenance or inspection. Door frames shall be one piece, welded, 14 gage galvanized steel with integral gutter lips, Access doors shall be fully gasketed around entire perimeter with easily replaceable gaskets.

D. Insulation: Insulation shall be neoprene coated NFPA-90A approved glass fiber. Seal all insulation seams with formed steel angles such that all edges are rendered smooth to airflow. Insulation for the bottom of the unit shall be glued and pinned to the under side of the unit so the floor of the unit will be a walk-work area.

E. Fans: Unit fan assemblies shall be of type as indicated on the drawings and schedules. Plug type fans shall be arranged with both fan bearings on the same side of the wheel. No obstruction will be permitted in the fan inlet.

F. Filter Section: Filter section shall be factory fabricated as part of air handling unit. Filters shall be arranged for face loading into positive sealing manufacturer’s filter frames. Frames shall be bolted or welded into filter section by air handling unit manufacturer.

G. Gas Fire Furnace Section: Provide factory installed outdoor, weatherproof, AGA certified indirect fired furnace for capacity as shown on the schedule. Minimum efficiency shall be 80 percent. Provide 409 stainless steel heat exchanger and burner. Include 2-stage gas valve, spark ignition; electronic flame supervision, high limit safety control, redundant gas valve and fan switch.

H. Dampers: Dampers shall be low leak construction. Frames shall be 7.0" wide with double flanges for structural rigidity. Damper blades shall be enclosed in frame. Damper frame shall be minimum 16.0 gauge galvanized steel welded continuously at all corners and shall be coated with 2 coats of polyurethane paint.

I. Indirect Evaporative Cooling Sections: The indirect evaporative cooling sections shall be factory assembled packages complete with indirect evaporative heat exchangers, wetside fans, water pumps, intake weatherhood, filter section, discharge supply air duct connections, water distribution manifold and nozzles moisture eliminators, float valve, overflow and drain.

J. Indirect Evaporative Heat Exchanger: The indirect evaporative heat exchanger shall be the air-to-air type, constructed with non-corrosive, non-metallic vertical tubes to eliminate stress and protect from calcium deposits. The header shall be solvent welded to the tubes to insure and airtight and watertight seal. The water shall be evaporated on the inside of the tubes to insure only sensible cooling; the minimum heat exchanger efficiency shall b as scheduled in the Contract Drawings.

K. Roof Curbs: Manufacturer’s standard construction, 14 inch high minimum, insulated and having a corrosive protective coating, complete with factory installed wood nailer and drain nipple. Roof curbs shall be tapered to math roof scope.

2.19 GAS FIRED FURNACE

A. General Product Requirements:

1. Built-in thermostats furnished with equipment shall meet requirements of the California Energy Code, Subchapter 2, All Occupancies-Mandatory Requirements for the Manufacture, Construction and Installation of Systems, Equipment and Building Components.

2. Minimum efficiency of equipment shall meet or exceed requirements of the California Energy Code, Subchapter 2, Mandatory Requirements for Space-Conditioning Equipment and Table 1-C, Efficiency Requirements for space-Conditioning Equipment.

3. Equipment shall be listed on the California Energy Commission’s (CEC) list of approved equipment and shall be certified, by the manufacturer, as complying with the CEC Appliance Efficiency Standards.

4. Air conditioners shall be designed for and charged with non-ozone-depleting refrigerant.

5. Disconnect switches, where provided, shall be accessible from outside control panel with control circuit transformer wired on disconnected side of the switch.

6. Provide smoke detectors to automatically shutdown the system upon detecting the presence of smoke as required by NFPA 90A.

B. Furnace:

1. Requirements: Provide furnace consisting of indoor unit and remote air-to-air outdoor unit rated in accordance with ANSI A21.47 and ARI 210/240. Design separate units to be used together, and base ratings on the use of the matched assemblies. Provide units complete with air filters, control dampers, base, factory installed internal insulation, controls, wiring, and internal refrigerant piping.

2. Indoor Unit:

   a. Indoor unit shall be completely assembled to form and integral unit in which all components are properly matched. Unit shall be located indoor as indicated. Unit shall be capable of both continuous 24-hour per day operation, and intermittent operation.

   b. Indoor unit shall consist of cabinet type centrifugal fan section, gas burner, heat exchanger, direct expansion cooling coil section, and air filter and mixing box with dampers where indicated. Each section shall be constructed of a steel frame with removable steel panels. Section shall be bolted together to make up a single unit. Bolting flanges shall be sealed to prevent leakages. Steel transition pieces or flexible connections shall be provided where shown or required.

   c. Access panels shall be provided for each section and both faces of the coils.

   d. Inlet and outlet section of the unit for ducted air delivery shall have flanges or collars for attachment of flexible connections or ducts.

   e. Blower shall be centrifugal fan suitable for cabinet type design. Fan section shall consist of one or more fan wheels as required. Fan housing shall be constructed of steel members and plates reinforced for maximum rigidity. Shaft bearings shall be supported independently from the fan section panels. Blower shall be statically and dynamically balanced. Belt drives shall be designed for 50 percent overload capacity and shall be provided with adjustable pulleys. Blower-motor assembly shall be resiliently mounted on spring vibration isolators.

   f. Coil section shall consist of a cooling coil where indicate. Cooling coils shall be direct expansion type constructed of aluminum fins mechanically bonded to seamless copper tubes. Coil section shall be arranged to allow removal of the coils from either side of the housing, unless otherwise indicated. The coil section shall be provided with a waterproofed and insulated galvanized steel drain pan with a drain connection.

   g. Indoor unit cabinet shall be insulated with one-inch thick 1.5 pounds per cubic feet density glass fiber insulation. Unit cabinet shall be coated with baked enamel finish.

   h. Filter: Provide either integral or remote filters, as indicated. Integral filters shall be 1 inch deep low efficiency filters as specified in this section. The remote filters shall include 2 inches deep low efficiency filters and high efficiency bag filters in side servicing housing as specified in this section.

i. Fan motors shall be premium, highest efficiency and shall conform to NEMA MG 1. Motor starters shall conform to NEMA ICS 1. Motors shall be totally enclosed fan cooled. Motor starters shall be magnetic across-the-line type. Floor mounted indoor unit starters and controls shall be enclosed in NEMA 4X enclosure. Ceiling suspended indoor unit starters and controls shall be enclosed in NEMA 12 general purpose enclosure. All starter panels shall be furnished with circuit breaker main disconnect switch.

j. Heat exchanger shall be of aluminized steel. Burners shall be single-port non-linting, providing even heat distribution.

k. Gas controls shall provide for automatic shut-off if flame goes out. Burner ignition shall be via spark-ignition. Continuous burning pilots shall not be allowed.

3. Outdoor Unit:

a. Unit and components shall be completely factory assembled, pre-wired, tested, and ready to operate. Unit shall be capable of operating at rated capacity at the specified ambient air temperature and conditions. Equipment shall be suitable for outdoor installation at rooftop or ground level locations as shown. Unit shall be capable of both continuous operation and intermittent operation.

b. Each unit shall have either one or two completely independent refrigeration circuits as shown. Where two circuits are shown for and individual unit, each circuit shall be suitable for load sharing and/or standby duty.

c. Each unit shall be provided with either one or two compressors as required by the specified refrigeration circuits. Compressors shall be reciprocating, serviceable semi-hermetic, or hermetic type with crankcase heater, with entire running gear assembly internally suspended, and externally mounted on resilient rubber mounts. Suction and discharge valves shall have hardened seats. Unit shall have multiple step capacity control, spring-loaded relief valve, and removable heads with unloader timers. Compressor motor shall be provided with heat sensing elements embedded in the motor winding. All motors over 5 HP shall have variable speed control.

d. Condenser coils shall be air-cooled type with minimum 3/8-inch outside diameter seamless copper tubing. Coil shall have aluminum plate fins mechanically bonded to copper tubes.

e. Condenser fans shall be statically and dynamically balanced propeller type, direct driven and discharging upward.

f. Unit cabinet shall be constructed of galvanized steel, bonderized and coated with baked enamel. Cabinet panels shall be removable for service access to all operating components.

g. Integral refrigerant piping shall be hard-drawn type ACR copper tubing with wrought-copper fittings and brazed joints.

h. Compressor motor shall be rated for electric power characteristics as indicated. Motor shall conform to NEMA MG 1. Starters shall conform to NEMA ICS 1. Motor shall be constant speed, low-starting current and high-torque squirrel-cage induction type, and shall have a magnetic across-the-line motor starter.

i. Provide each outdoor unit with unit mounted disconnect switch.

4. Unit Controls:

a. Unit controls shall be housed in a NEMA 4Z, for outdoor units and floor mounted indoor units, and NEMA 12 for other indoor units integral with the unit cabinet. The following control devices shall be provided:

1) Compressor motor magnetic starters.

2) Condenser fan motor magnetic starters.

3) Control power transformers.

4) Occupied/Unoccupied program relay.

5) Override timer.

b. Protective devices shall be designed to control operation under the following conditions:

1) Motor overload.

2) Under-voltage.

3) Locked rotor.

4) Excessive winding temperature.

5) High and low operating pressures.

6) Loss of refrigeration.

7) Compressor rapid cycling.

c. Where two compressors per unit are required, switch for alternating lead compressor timer shall be provided.

2.20 COOLING TOWERS

A. Fabricated package cooling towers using manufacturer’s standard design, materials, and construction in accordance with published product information, except as otherwise indicated in the Contract Documents.

B. Structural Design Requirements: Design structural system for the following live loading in addition to tower dead-loads and operating-loads:

1. Wind Loading: 100 MPH on exposed vertical surfaces.

2. Earthquake Resistance: Per CBC Seismic Zone 4 requirements.

C. Other Design Requirements: The cooling towers total drift shall not exceed 0.02 percent of the maximum water flow.

D. Steel panel and structural elements shall be constructed from heavy gage Type 304 stainless steel.

E. Casings: Provide fiberglass-reinforced polyester (FRP) panels fabricated and installed by manufacturer to make tower watertight, and ensure access to all components that require cleaning by providing large hinged doors on both sides of the tower. Provide interior doors between cells and galvanized steel internal walkways.

F. Collecting Basin and Sump: Provide stainless steel integral type collecting basin and sump with lift-out strainer with openings smaller than nozzle orifices, and with connections for drain, overflow, and water make-up. Design and install to support water and to ensure water tightness. All cells to have connections for independent cell operation. Provide flume box with gate in each cell. Provide walkway, ladder, and working platform in each cooling tower basin and door for each cell. Provide door between cells.

G. Wetted-Surface Fill: Provide vertical sheets of polyvinyl chloride plastic having flame spread rating of no greater than 5 per ASTM E 84. Fabricate into wave-formed configurations installed by manufacturer to ensure break-up of water into droplets.

H. Drift Eliminators: Provide polyvinyl chloride plastic, having flame spread rating of 5 per ASTM E 84. Fabricate by manufacturer into three-pass configuration to limit drift-loss to indicated maximum percentage of circulating-water flow-rate.

I. Louvers: Provide FRP louvers designed and installed by manufacturer, and of sufficient thickness and rigidity to prevent visible sagging:

J. Provide a single water inlet connection with a chamber that automatically balances the flow to the hot water basins or provide two inlets with butterfly valves for balancing flow to each distribution basin and for shut off during servicing.

K. Water Distribution System: The following materials designed and installed by manufacturer to ensure even distribution of water over wetted- surface-fill.

1. Schedule 40 PVC pipe header and removable schedule 40 PVC pipe branches with balancing chamber, access door, and removable strainer.

2. Nozzles: Provide removable plastic, brass, or ceramic nozzles. Pressure Drop: Maximum pressure drop of 1 PSI.

3. Provide flow control valves for balancing flow to each distribution basin and for shut-off during servicing, or provide accessible balancing chamber with strainer and internal risers for gravity water distribution.

L. Basin Covers: Provide high density polyethylene covers, removable and with handles, installed by manufacturer to prevent debris from entering basin and to inhibit algae growth by eliminating sunlight.

M. Handrails: Provide galvanized steel pipe rails of required height above or inside tower. Include knee and toe rails of required diameter and heights if required by code. (Required only with top inlet towers where access is required at top of unit.)

N. Ladders: Provide galvanized steel or aluminum ladder, to top of cooling tower internally or externally as required to access all working surfaces on two sides including working platform.

1. Safety Cage: Include safety cage of galvanized steel or aluminum. (Only required where access to top of tower is required.)

O. Water Level Control: Provide plastic mechanical float ball with adjustable linkage.

P. Fans and Drives: Provide cast-aluminum propeller fan of adjustable-pitch (factory adjusted) type with gear-drive (or power band NJ-drive) including speed reducer, designed for single-speed operation installed by manufacturer. Provide low oil level alarm and wiring (only with gear drive) for each cell. All fan drives of 5 HP and above shall have variable speed controls.

Q. Fan Bearings: Provide tapered roller or ball bearings installed by manufacturer.

R. Vibration Cutout Switch: Provide switch (for each cell), wired by contractor to de-energize fan motors if excessive vibration occurs due to fan imbalance.

S. Assemble components by one of the following methods:

1. Use stainless fasteners and accessories to assemble components, except for cold water basin. Hot and cold water basin shall be welded stainless steel.

2. Weld metal seams and joints.

T. Finishes:

1. Apply phosphatized pretreatment on zinc coated surfaces which have not been mill-phosphatized or polymer-coated. Apply gasoline-soluble rust preventative compound on ferrous parts which cannot be galvanized, including shafts and machined parts.

2. Finish components with zinc-coated metal surfaces by one of the following methods:

a. Coat abraded areas and welded areas with galvanizing repair paint. Finish-paint exposed surfaces with zinc chromatized paint.

b. Provide 2-1/4 oz. (per sq. ft. of sheet) zinc coating on basin and sump, after fabrication, by hot-dip galvanizing process. Coat abraded areas and welded areas of work with galvanizing repair paint.

c. Apply to metal surfaces which are not galvanized, a zinc-rich paint equivalent to hot-dipped galvanized steel.

U. Provide removable standpipe overflow for flush-out basin cleaning.

V. The cooling towers fill materials thickness shall not be less than 13 mils.

W. The support structure, fan deck, and fan cylinder shall be protected with the corrosion protection system, applied by the cooling tower manufacturer at the manufacturing plant.

2.21 AIR FILTERS

A. Filter Type: Type and capacity of filters and type of filter holding system shall be as indicated.

B. Low Efficiency Filters: Replaceable, throwaway, panel filters, 2 inches deep, 24 inches by 24 inches face or as required, fiberglass, heavy duty, with laminated backing and sprayed with non-flammable adhesive, UL Class ll, framed in throwaway fiberglass casing, and sandwiched between perforated metal grilles. Provide filters with rated maximum face velocity of 500 fpm, initial resistance of not grater than 0.30 inch water gate (w.g.), final rated resistance of 0.50 inch w.g., and average arrestance of 80 percent.

C. High Efficiency Bag Filters: Replaceable, throwaway, fiberglass media, with 10 pleats, bags, 22 inches deep, thread stitched, 24 inches by 24 inches face or as required, with corrosion resistant frame, and minimum of 70 square feet of filter media. Provide filters with rated maximum face velocity of 500 fpm, initial resistance 0f 0.40 inch w.g. with 80 percent to 85 percent ASHRAE 52.1 dustspot efficiency, and final rated resistance of 1.0 inch w.g.

D. Front and Rear Access Filter Frames: Provide filter bank framing system, constructed of aluminum framing members having minimum thickness of 0.09 inch. Provide for either upstream (front) or downstream (rear) filter servicing. Cut to size and pre-punch members for each assembly into modules of size and capacity as indicated. Provide permanently gasketed framing members to prevent bypass of unfiltered air. If vertical support members are required to prevent deflection of horizontal members, install so as not to interfere with either installation or operation of filters. Incorporate separate track for pre-filters, removable from front, or removable from back after removal of after-filters. Provide factory-installed positive sealing device for each row of filters, to insure seal between gasketed filter elements. Provide hardware necessary for field assembly.

E. Side Servicing Housings: Provide factory-assembled side servicing housings with flanges for insertion into ductwork system as indicated: housing shall be constructed of 16 gage galvanized steel. Provide integral pre-filter tracks to accommodate 2 inches pre-filters. Provide access doors with continuous gasketing on perimeter and positive locking devices. Incorporate positive-sealing gasket material on channels to seal top and bottom of filter cartridge frames to prevent bypass. Arrange so filter cartridge can be loaded from either access door.

F. Spare Media and Filters:

1. In the original installation of filters and filtering equipment, two replacements of filters as herein specified shall be provide for each filter.

2. Mark each media carton with a code number applying to the series of tests that have been carried out by the manufacturer in accordance with ASHRAE and ARI requirements; AFI Performance Test, Test for Uniformity of Resistance, Media Compressibility and Strength Test, Weight Test for Quantity of Adhesive, and Weight Test for Quantity of Fiber.

3. Any filter media installed in air handling systems used to provide temporary service shall not be considered a part of the final installation at Substantial Completion.

2.22 BOILER STACK

A. Boiler stack and fittings shall be factory fabricated fuel chimney, double wall, air insulated, all metal construction and shall include straight section stack, elbows if required, roof support, flashing, storm collar, and vent cap.

B. Inner Pipe: Fabricated of Type 304 stainless steel with nominal 1 inch air space between walls.

C. Outer Jacket: Aluminum coated steel.

D. Joints: Stack and vents shall have snap-lock joints or compression band joints that provide tight sealing and rigid joints.

E. Mechanical Boiler Stack Vent System

1. Provide boiler stack vent system for multiple boiler arrangements where indicated. Otherwise, stacks shall not be manifolded to one single stack.

2. Mechanical boiler stack vent system shall consist of two variable speed flue exhaust fans on a factory fabricated steel plenum mounted on the roof at the top of the boiler stack system. System shall be controlled maintaining a pre-set negative draft pressure.

3. Fans:

   a. Provide tow fans with a total capacity equal to or greater than the maximum flue gas capacity and at the required pressure to ensure a negative pressure in the entire boiler stack system.

   b. Chimney fans shall handle a flue gas temperature up to 640 degrees Fahrenheit measured at the flue exit point.

   c. Fans shall be ETL listed to UL 378 for installation at the boiler stack termination point.

   d. Fans shall provide full modulation from minimum load to maximum load.

   e. The entire mechanical boiler stack vent system shall be manufactured at an ISO 9001 certified and audited plant.

   f. Fans shall be manufactured in cast aluminum, type SAE331, with a minimum thickness of 3/16 inch.

g. Housings shall be corrosion resistant and protected by factory applied paint finish.

h. The impellers shall be made of cast aluminum and be completely balanced.

i. The discharge area design shall insure minimum soot buildup and provide easy access for cleaning and servicing.

4. Motors:

a. Use maintenance free split capacitor motors, completely enclosed, with pro-lubricated and sealed ball bearings requiring no further maintenance.

b. Motors over 5 HP shall be premium high efficiency and equipped with variable speed or multiple speed control, Class H.

5. Exhaust Fan Plenum: A factory fabricated 12 gage galvanized steel plenum of welded construction shall be provided for the system installation. Welded seams shall be coated with a zinc primer.

6. Constant Pressure Regulator: A constant pressure regulator shall be furnished for automatic modulation of boiler stack fan speed. Controls shall maintain a pre-set negative draft pressure. Control box shall have dial settings between zero and 1.0 inch water column with indicator lights. Control shall include a sensor and boiler stack probe.

7. Fan Proving Switch:

a. A fan proving switch shall be provided with sensing probe and tubing. Switch shall have and adjustable set point between 0.07 inch and 0.15 inch water column. Switch shall be rated at 1 x 120 V, 15 A.

b. If fan proving switch indicates boiler stack exhaust fans are inoperative, hot water boilers shall be shut down.

8. Warranty:

a. Mechanical boiler stack vent system shall be provided with a two-year warranty against corrosion perforation.

b. The system shall be designed by the manufacturer in accordance with the terms of the manufacturer’s warranty.

9. Structural Support: Mechanical boiler stack vent assembly shall be seismically braced at the roof, using steel guy wires.

10. Expansion Joints: Provide an expansion joint section on the boiler stack immediately below the mechanical boiler stack vent system.

PART 3 – EXECUTION

3.01 INSTALLATION GENERAL

A. Install unitary air-conditioning equipment, heat pumps, heating and ventilating units, Boilers, pumps, unit heaters, coils and electric heating equipment as indicated, plumb and level, firmly anchored, in accordance with the respective manufacturer's installation instructions.

B. Install accessories, appurtenances, piping and controls, including supports, vibration isolators, stands, guides, anchors, clamps, and brackets as indicated.

C. Anchor bolt heads shall have welded on plates, and shall be embedded in the concrete. Equipment bases shall be leveled and grouted in with non-shrink grout. Anchor plates shall be hot-dip galvanized as specified in Section 05 50 00, Metal Fabrications.

D. Locate equipment as indicated, having manufacturers' recommended working space available for servicing. Provide electric isolation between dissimilar metals.

E. Install pumps according to manufacturer's written installation and alignment instructions.

F. Install pumps in locations indicated and arranged to provide access for periodic maintenance, including removal of motors, impellers, couplings, and accessories.

G. Support pumps and piping separately so that piping is not supported by pumps.

H. Set base-mounted pumps on concrete foundation. Disconnect coupling halves before setting. Do not reconnect couplings until alignment operations have been completed.

I. Support pump base plate on rectangular metal blocks and shims, or on metal wedges with small taper, at points near foundation bolts to provide a gap of 3/4 inch to 1-1/2 inches between pump base and foundation for grouting. Adjust metal supports or wedges until pump and driver shafts are level. Check coupling faces and suction and discharge flanges of pump to verify that they are level and plumb.

J. Install furnace and air-conditioning units as indicated, plumb and level, firmly anchored, in accordance with the respective manufacturer's installation instructions. Install accessories, appurtenances, piping and controls, including supports, vibration isolators, stands, guides, anchors, clamps, and brackets as indicated.

K. Anchor bolt heads shall have welded-on plates, and shall be embedded in the concrete. Equipment bases shall be leveled and grouted-in with non-shrink grout. Anchor plated shall be hot-dip galvanized as specified in Contract Specifications Section 05 50 00, Metal Fabrications.

L. Locate equipment as indicated, having manufacturer's recommended working space available for servicing. Provide electric isolation between dissimilar metals.

M. Boiler Stack and Gas Vent Installation: Comply with manufacturer's recommendations, Uniform Mechanical Code, and local code requirements. Fasten and support the stack and vent system securely to building structure. Maintain required clearance from combustible materials. Keep offsets and lengths of horizontal pipe to minimum unless indicated otherwise.

N. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring-diagram submittal to electrical installer. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer. Install control, alarm, and other required wiring.

O. Refrigeration Piping: Refer to Section 23 23 00, Refrigerant Piping, for applicable requirements. Connect refrigeration piping to split type units, as indicated.

P. Drain Piping: Connect unit drain to nearest indirect waste connection. Provide trap at drain pan; construct trap at least 1 inch deeper than fan pressure in inches of water.

Q. Ductwork: Refer to Section 23 31 00, HVAC Ducts and Casings, for applicable requirements. Connect supply and return ducts to unit with flexible duct connections where duct connections are indicated. Provide transitions to exactly match unit duct connection size. Use long radius sweep elbows.

R. Heating and Ventilating Unit Installation

1. Section 01 45 00, Quality Control: Manufacturer's instructions.
2. Install in accordance with ARI 430.
3. Bolt sections together with gaskets. Isolate fan section with flexible duct connections.
4. Install flexible connections between fan inlet and discharge ductwork. Ensure metal bands of connectors are parallel with minimum one inch (25 mm) flex between ductwork and fan while running.
5. Install assembled unit on vibration isolators. Install isolated fans with resilient mountings and flexible electrical leads. Install restraining snubbers as required. Adjust snubbers to prevent tension in flexible connectors when fan is operating.
6. Provide sheaves required for final air balance.
7. Make connections to coils with unions or flanges.

S. Hot Water Boiler Installation

1. Install in accordance with manufacturer's instructions.
2. Install in accordance with NFPA 54.
3. Install boiler on existing concrete housekeeping base.

4. Provide connection of natural gas service in accordance with NFPA 54.

5. Provide piping connections and accessories as indicated on Reference Drawings to duplicate and integrate with existing system.

6. Pipe relief valves to nearest floor drain.

7. Connect to electrical service.

8. Mount thermometer in boiler breeching within 12 inches (300 mm) of flue nozzle.

9. Reconnect boiler to existing expansion tank and complete related existing accessories.

10. Install new recirculation pumps and piping. Piping shall replicate existing accessories.

T. Recirculating Pump Installation:

1. Install in accordance with manufacturer's instructions.

2. Provide access space around pumps for service. Provide no less than minimum as recommended by manufacturer.

3. Decrease from line size with long radius reducing elbows or reducers. Support piping adjacent to pump such that no weight is carried on pump casings. For base mounted pumps, provide supports under elbows on pump suction and discharge line sizes 4 inches (102 mm) and over.

4. Provide line sized shut-off valve and strainer on pump suction, and line sized soft seat check valve and balancing valve on pump discharge.

5. Provide air cock and drain connection on horizontal pump casings.

6. Provide drains for bases and seals, piped to and discharging into floor drains.

7. Check, align and certify alignment of base mounted pumps prior to start-up.

8. Install base mounted pumps on concrete housekeeping base, with anchor bolts, set and level, and grout in place. Refer to Section 03 61 11, Non-Shrink Grout.

   a. Lubricate pumps before start-up.

U. Air Coils: Install air coils in accordance with manufacturers written instructions.

1. Install in ducts and casings in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible.

   a. Support coil sections independent of piping on steel channel or double angle frames and secure to casings.

   b. Provide frames for maximum three coil sections.

c. Arrange supports to avoid piercing drain pans.

d. Provide airtight seal between coil and duct or casing.

2. Protect coils to prevent damage to fins and flanges. Comb out bent fins.

3. Install coils level. Install cleanable tube coils with 1:50 pitch.

4. Make connection to coils with unions and flanges.

3.02 COOLING TOWER INSPECTION

A. Examine areas and conditions under which packaged cooling towers are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to installer.

3.03 COOLING TOWER INSTALLATION

A. General: Install cooling towers where indicated, in accordance with equipment manufacturer's written instructions and with recognized industry practices, to ensure that cooling towers comply with requirements and serve intended purposes.

B. Access: Provide access and service space around and over cooling towers as indicated, but in no case less than that recommended by manufacturer.

C. Placement: Mount unit on structural steel. Install gaskets or sealants between cooling tower cells. Level units to tolerance of 1/8 inch in 10 feet -0 inch, in both directions. Multiple cells shall be at equal elevations. Provide and install bolts per manufacturer's recommendations.

D. Cooling towers pipe connections: Coordinate the pipe connections at the bottom of the unit with the steel supports: “”Provide adequate clearance and space for all of the piping. The contractor shall modify the pipe connections or supports if required without and additional cost to the university. The contractor shall provide shop drawing for piping and supporting structure before ordering the cooling towers and building the support structure.

E. Condenser Water Piping: Provide flanged connections to cooling tower. Pitch lines so water will drain into sump. Connect inlets to cooling tower with shutoff valve, and balancing valve (if 2 or more inlets). Connect outlets with shutoff valves.

F. Make-up and Water Piping: Provide flanged connections to cooling tower. Pitch lines so water will drain into sump.

G. Drain Piping: Connect drain, overflow, and bleed lines to cooling tower as indicated, full size of connection on cooling tower.

3.04 PAINTING

A. Unless otherwise indicated, paint outdoor equipment in accordance with Section 09 91 00, Painting. Indoor equipment shall be touched up with factory-supplied paint applied in accordance with the manufacturer's instructions.

3.05 COOLING TOWER CLEANING, ADJUSTING AND TESTING

A. Cleaning: Clean inside of cooling tower thoroughly before filling for start-up. Clean factory- finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

B. Start-up: Comply with manufacturer's instructions for filling and start-up of operation, but not less than the following:

1. Verify lubrication of rotating parts; lubricate as needed.
2. Verify fan rotation direction.
3. Verify that motor amperage is in accordance with manufacturer's data.
4. Balance condenser water flow to each tower and to each inlet for multiple inlet towers.
5. Adjust water level control for proper operating level.
6. Adjust bleed valve for indicated percentage of circulated water volume.
7. Adjust temperature controls and verify operation.

C. Operation Test: Test each cooling tower to show that it will operate in accordance with indicated requirements. Perform field test in accordance with CTI ATC-105. This test not required if towers are already CTI certified.

3.06 START-UP SERVICE

A. Provide the services of a factory-authorized service representative to inspect the installation and connections and to provide initial start-up service. Services shall include a complete operational check and demonstration of the system to ensure proper operation.

B. Provide instructions to the District's maintenance personnel on proper operation and maintenance procedures in accordance with the requirements of Section 01 79 00, Demonstration and Training.

C. Hot Water Boiler Manufacturer's Field Services

1. Prepare and start systems.
2. Provide field representative for starting unit and training operator.

3.07 FIELD QUALITY CONTROL

A. Perform start-up tests in conformance with Section 23 05 93, Testing, Adjusting and Balancing for HVAC, of all heating and air-conditioning equipment. Perform tests in accordance with respective manufacturer's instructions and referenced codes and standards.

B. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment. Retest replaced controls and equipment.

END OF SECTION 23 81 00

SECTION 26 05 17

DRY-TYPE TRANSFORMERS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Dry-type transformers.

1.02 MEASUREMENT AND PAYMENT

A. General: Dry-type transformers, as specified herein, will not be measured separately for payment but will be paid for as part of the Contract lump-sum price for Electrical Work as indicated in the Bid Schedule of the Bid Form.

1.03 REFERENCES

A. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE C57.12.01 Standard for General Requirements for Dry-Type Distribution and Power Transformers

2. IEEE C57.12.91 Standard Test Code for Dry-Type Distribution and Power Transformers

B. National Electrical Manufacturers Association (NEMA):

1. NEMA ST 20 Dry Type Transformers for General Applications

C. National Fire Protection Association (NFPA):

1. NFPA 70 National Electrical Code (NEC)

1.04 REGULATORY REQUIREMENTS

A. Refer to Section 20 70 26, Common Materials and Methods for Electrical Systems, for requirements.

B. California Code of Regulations (CCR):

1. Title 24, Part 3 California Electrical Code

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Product Data: Submit manufacturer’s product data of transformers.

C. Operation and Maintenance Data: Submit maintenance data and operating instructions in accordance with Section 01 78 23, Operation and Maintenance Data. Include the following requirements:

1. Description of the equipment and its components;

2. Manufacturer's operating and maintenance instructions, parts list, illustrations, and diagram of components;

3. Recommended list of spare parts; and

4. Wiring diagram.

D. Test Reports: Submit certified field test reports.

1.06 QUALITY ASSURANCE

A. Select a transformer manufacturer who has been regularly engaged in the manufacture of equipment and facilities similar to BART rail applications.

B. Conform to NEMA ST 20 and California Electrical Code, or National Electrical Code, as applicable.

C. Equipment of the same type, size, rating, functional characteristics, and make shall be interchangeable

1.07 DELIVERY, STORAGE AND HANDLING

A. Ship each unit securely wrapped, packaged, and labeled for safe handling of shipment and to avoid damage.

B. Store transformers in secure and dry storage facility.

PART 2 – PRODUCTS

2.01 EQUIPMENT, APPURTENANCES AND ACCESSORIES

A. Dry-Type Transformers: Provide two winding, NEMA Premium compliant energy-efficient with copper winding type, Class H transformer with full capacity taps on the high voltage winding in accordance with NEMA ST 20. Autotransformer type is not acceptable. Transformers smaller than 30 kVA shall have the core and coil completely resin-encapsulated and shall have minimum 185 degrees Celsius insulation with 115 degrees Celsius rise. Transformers larger than 30 kVA shall have 220 degrees Celsius insulation with 150 degrees Celsius rise.

B. Terminals: Terminals of transformer windings shall be extended from the coil for external connection. Proper terminal identification shall be provided.

C. Noise Level: Noise level shall not exceed the following values when measured in accordance with NEMA ST 20:

1-9 kVA:	40 dBA
10-50 kVA:	45 dBA
51-75 kVA:	50 dBA

D. Enclosures: Equipment enclosures shall be of NEMA classification suitable for the environment to which equipment is exposed. Where NEMA 4 watertight enclosures are required, ensure that bolt down covers do not cause accessibility problems. NEMA 4 enclosures shall be used in subway locations and in areas exposed to rain, or water, or high humidity environment.

E. Finish: Metallic surfaces shall be thoroughly cleaned, degreased, primed with an approved corrosion-inhibitive primer, and finished with a heavy-duty, industrial-grade polyurethane enamel.

F. Nameplate: Provide nameplates showing transformer number. Nameplates shall conform to the requirements of Section 20 70 26, Common Materials and Methods for Electrical Systems

2.02 FACTORY TESTS

A. Perform the following factory tests on each transformer unit in accordance with IEEE C57.12.01 and IEEE C57.12.91:

1. Resistance measurements of all windings on the rated voltage connections and on all tap connections of each transformer;
2. Ratio tests on the rated voltage connections and on all tap connections;
3. Phase-relation and polarity tests on the rated voltage connections;
4. No-load losses and excitation current at rated voltage on the rated voltage connections;
5. Impedance and load losses at rated current and rated frequency on the rated voltage connections of each transformer;
6. Applied and induced potential tests;
7. Regulation and efficiency at rated load and voltage;
8. Insulation resistance tests (high voltage to ground, low voltage to ground, high voltage to low voltage); and
9. Perform temperature tests in accordance with IEEE C57.12.91.

B. Provide certified test reports of all tests.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install dry type transformers as indicated, in accordance with NEMA criteria, and as recommended by the manufacturer. Transformers shall be properly anchored, and the installation shall conform with applicable code requirements for seismic restraints. Transformers shall be maintained dust-free during the construction period and until accepted by the District.

3.02 FIELD TESTS

A. Verify that circuits are connected in accordance with the applicable wiring diagrams.

B. Verify that circuits are continuous and free from short circuits.

C. Verify that the insulation resistance to ground of non grounded conductors is megger tested to not less than 10 MΩ.

END OF SECTION 26 05 17

SECTION 26 05 24

LOW VOLTAGE WIRES AND CABLE

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Wire and cable markings.

B. 600 volt single conductor cable.

C. Multiple conductor cable.

D. Fixture wire.

E. Bare conductor.

F. Low-voltage control circuit wire.

G. Thermocouple cable.

H. Color coding of conductors (600V).

I. Cable supports and fasteners.

J. Conductor bundling straps.

1.02 RELATED SECTIONS

A. Section 20 70 26, Common Materials and Methods for Electrical Systems.

B. Section 20 50 13, Raceways for Facility Services.

1.03 MEASUREMENT AND PAYMENT

A. General: Low voltage wires and cables, as specified herein, will not be measured separately for payment but will be paid for as part of the Contract lump-sum price for the related item of work in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. The American Railway Engineering and Maintenance of Way Association (AREMA):

1. Communications & Signal Manual

B. Engineering Sciences Data Unit (ESDU):

1. ESDU 06018 Temperature Measurement: Thermocouples

C. American Society for Testing and Materials (ASTM):

1.	ASTM B3	Standard Specification for Soft or Annealed Copper Wire
2.	ASTM B8	Standard Specification for Concentric-Lay-Stranded Copper, Conductors, Hard, Medium-Hard, or Soft
3.	ASTM B33	Standard Specification for Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes
4.	ASTM B172	Standard Specification for Rope-Lay-Stranded Copper Conductors Having Bunch-Stranded Members, for Electrical Conductors
5.	ASTM B189	Standard Specification for Lead-Coated and Lead-Alloy-Coated Soft Copper Wire for Electrical Purposes
6.	ASTM D2671	Standard Test Methods for Heat-Shrinkable Tubing for Electrical Use
7.	ASTM E662	Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials

D. Insulated Cable Engineers Association, Inc. (ICEA):

1.	ICEA S-84-608	Telecommunications Cable Filled, Polyolefin Insulated, Copper Conductor Technical Requirements
2.	ICEA T-28-562	Test Method for Measurement of Hot Creep of Polymeric Insulations

E. Institute of Electrical and Electronics Engineers (IEEE):

1.	IEEE 1202	IEEE Standard for Flame-Propagation Testing of Wire and Cable

F. National Electrical Manufacturers Association (NEMA):

1.	NEMA HP 100.2	High Temperature Instrumentation and Control Cables Insulated and Jacketed with ETFE Fluoropolymers
2.	NEMA WC 70	Power Cable Rated 2000 Volts or Less for the Distribution of Electrical Energy

G. National Fire Protection Association (NFPA):

1.	NFPA 70	National Electrical Code (NEC)
2.	NFPA 130	Standard for Fixed Guideway Transit and Passenger Rail Systems

H. Underwriters Laboratories Inc. (UL):

1.	UL 56	Standard for Strut-Type Channel Raceways and Fittings
2.	UL 62	Standard for Safety Flexible Cord and Cables
3.	UL 719	Standard for Safety Nonmetallic-Sheathed Cables
4.	UL 1581	Standard for Safety Reference Standard for Electrical Wires, Cables, and Flexible Cords
5.	UL 1666	Standard for Safety Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts
6.	UL 2196	Standard for Fire Test for Circuit Integrity of Fire-Resistive Power Instrumentation, Control, and Data Cables

I. California Code of Regulations:

1.	Title 24, Part 2	California Building Code
2.	Title 24, Part 3	California Electrical Code

J. InterNational Electrical Testing Association (NETA):

1.	NETA ATS	Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

1.05 REGULATORY REQUIREMENTS

A. Refer to Section 20 70 26, Common Materials and Methods for Electrical Systems, for requirements.

1.06 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Submittal Requirements: Before installation of wires and cables, submit the following information for each type and size of wire and cable:

1. Manufacturer of wire and cable, and certificate of compliance;
2. Number and size of strands composing each conductor;
3. Conductor insulation composition type in accordance with California Electrical Code and thickness in mils;
4. Average overall diameter of finished wire and cable;

5. Minimum insulation resistance in megohms per 1000 feet at 30 degrees Celsius ambient;

6. Jacket composition and thickness in mils;

7. Total number of conductors per cable;

8. Shield material (if any) and thickness;

9. Conductor resistance and reactance in ohms per 1000 feet at 25 degrees Celsius ambient; and

10. Conductor ampacities at 30 degrees Celsius ambient air temperature and at 20 degrees Celsius ambient earth temperature, and 100 percent load factor for 600V wire and cable.

11. Report with cable pulling tension calculation;

12. Field and commissioning test results in accordance with NETA standards;

13. Text for cable identification tags with the corresponding location to be applied.

1.07 DELIVERY, STORAGE AND HANDLING

A. Ship each unit securely wrapped, packaged, and labeled for safe handling in shipment and to avoid damage.

B. Store wire and cable in secure and dry storage facility.

PART 2 – PRODUCTS

2.01 WIRE AND CABLE MARKINGS

A. Wire and cable markings shall be in accordance with applicable NEMA and California Electrical Code requirements. Each item shall be UL listed.

2.02 600 VOLT SINGLE CONDUCTOR CABLE

A. Conductor Material: ICEA stranded or solid copper meeting requirements of ASTM B3, soft drawn.

B. Conductor Type: Unless specified otherwise, conductor types shall be as follows:

1. Size 12 AWG and Smaller: Solid conductor.

2. Size 10 AWG and Larger: Class B stranded.

3. Size 14 AWG to Size 1/0 AWG: California Electrical Code, Type THHN or THWN, polyvinyl chloride (PVC) thermoplastic insulated in accordance with NEMA WC 70. Cable shall be jacketed with clear polyamide nylon over the insulation.

4. Size 2/0 AWG and Larger: California Electrical Code, Type THWN-2/THHN-2, ethylene-propylene-rubber-insulated in accordance with NEMA WC 70.

C. Temperature Rating: Temperature ratings of cables shall be not less than 90 degrees Celsius.

D. Fire-Retardant Properties: Power cables for emergency fans and related equipment and emergency lighting cables shall pass the flame propagating criteria of IEEE 1202 and shall have a minimum circuit time of five minutes in the flame test of IEEE 1202. Type test certificate is required with every shipment of cables.

E. Low Smoke Low Halogen Properties: Cables used in train control rooms and tunnels shall have low smoke low halogen properties.

F. Insulation Rating: 600 V.

2.03 MULTIPLE CONDUCTOR CABLE

A. Provide multiple conductor cable conforming to NEMA WC 70, approved for use in cable tray, with the following additional requirements:

1. Number of Insulated Conductors: As indicated.

2. Provide multiple conductor cable for all power applications, except receptacles when installed in cable tray for sizes up to 4/0 AWG, as indicated.

3. Insulation: As specified above for single conductor cable.

4. Overall Covering: Cable shall be jacketed over the insulation.

5. Multiple conductor for control wire shall be minimum of 14 AWG stranded copper.

6. Insulation Rating: 600 V.

B. Multi-conductor cable shall be made by assembling individual or twisted pairs of insulated conductors into a tight cylindrical form using fillers that are compatible with other materials in the cable. The jacket used shall fit tightly to form a firm assembly.

C. For multiple conductor cable used for low voltage control circuits refer to Article 2.06.

2.04 FIXTURE WIRE

A. Provide fixture wire conforming to UL 62 and the following additional requirements:

1. Type: SF 2 silicone rubber insulated.

2. Conductor: Stranded copper conductor 16 AWG or larger as indicated.

2.05 BARE CONDUCTOR

A. Bare conductor: ASTM B3, Class B stranded, annealed soft drawn copper conductor, unless otherwise indicated, size as indicated. Bare conductor shall be used for ground wire only.

2.06 LOW VOLTAGE CONTROL CIRCUIT WIRE

A. Wires for low-voltage, 50 volts and below, control circuits shall be as follows:

1. For HVAC and irrigation control systems: solid, copper.

2. For fire protection systems: stranded, copper.

3. For all other control systems: subject to District approval.

2.07 THERMOCOUPLE CABLE

A. Provide thermocouple cable with solid conductors meeting requirements of ESDU 06018 and of type compatible with the thermocouple leads furnished with the motor or temperature sensor. Thermocouple cable shall have flame retardant insulation, pair-assembled with left hand lay, with flame retardant outer jacket, with overall shield, and UL-listed as Type PLTC.

2.08 COLOR CODING OF CONDUCTORS (600V)

A. Individual conductors of multi-conductor cables shall be identified by means of solid colors, stripes, or printing, unless otherwise approved by the Engineer.

1. Jacket Printing: Cables shall be identified by printing on the jacket or by a printed marker tape under the jacket. Information shall include, but not be limited to, the number of conductors, conductor size, voltage rating, name of manufacturer, manufacturer’s type, and date of manufacture. This information shall appear at intervals of not more than 30 inches.

2. Footage Marker Tape: Cables shall be provided with a footage marker tape under the jacket or by footage printing on the jacket.

3. Multi-conductor Switch-and-Lock Movement Control and Indication Cable Color Coding: Colors shall be durable and recognizable. Color sequence shall be in accordance with NEMA WC 70.

4. Two-Conductor Switch-and-Lock Movement: Color shall be black.

5. Power Cables: Color-coding of conductors for power cables shall be in accordance with NEMA WC 70, as follows:

Conductor	277/480 V	120/208 V
Phase A	Brown	Black
Phase B	Orange	Red
Phase C	Yellow	Blue
Neutral	White	White
Ground	Green	Green

B. Branch circuit phase conductors 10 AWG and smaller and all neutral and equipment grounding conductors shall be solid color insulation or solid color coating.

C. Phase conductors having colored tracers shall have background color other than white or green.

D. Solid color coatings and tracers shall have a strongly adherent paint or dye not injurious to the insulation and will not be obliterated by pulling into a conduit or raceway.

E. On site coloring of ends of conductor may be permitted by the Engineer upon receipt of satisfactory evidence that the Contractor is unable to order color coded wire and cable as specified. Provide certification from the cable manufacturer that the paint or dye proposed for field application is non-injurious to the insulation.

2.09 CABLE SUPPORTS AND FASTENERS

A. Cable supports, fasteners and channel inserts shall be UL 5B listed for the application and conform with California Electrical Code.

2.10 CONDUCTOR BUNDLING STRAPS

A. Provide conductor bundling straps formed from self-extinguishing nylon having a temperature range of minus 4.4 degrees Celsius to plus 185 degrees Celsius.

B. Equip each strap with a locking hub or head with a stainless steel locking barb on one end and a taper on the other end.

C. Wire and cable ties for installation outdoors and in exposed locations shall be ultraviolet resistant nylon material.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Coordinate installation of wires and cables with the requirements of Section 20 70 26, Common Materials and Methods for Electrical Systems, and Section 20 50 13, Raceways for Facility Services.

B. Provide wiring complete as indicated. Provide ample slack for field terminated wires and preformed cables with connections, including wires for motor loops, service connections, and extensions. In outlet or junction boxes provided for installation of equipment by others, tape ends of wires and install blank covers.

C. Do not bend cables during installation, either permanently or temporarily, to radii less than 12 times the outer diameters, except where conditions make the specified radius impractical and shorter radii are permitted by the California Electrical Code and NEMA WC 70.

D. Bundle cable and conductors neatly and securely with nylon straps located in branch circuit panelboards, cabinets, control boards, switchboards, and motor control centers. Use nylon bundling straps. Bundle power cables separately from control cables.

E. Install motor feeders, service connections, and extensions in accordance with the referenced codes. Install motor feeder in liquid-tight flexible conduit of 18 inches minimum length at motor conduit box.

F. For wire pulling, comply with the requirements of Section 20 70 26, Common Materials and Methods for Electrical Systems, Section 20 50 13, Raceways for Facility Services, and the following:

1. Install wire and cable in conduit as indicated. Do not pull wires into conduit until conduits and outlets have been thoroughly cleaned and swabbed. Do not use block and tackle or other mechanical means for pulling conductors smaller than 2 AWG in raceways.

2. Provide suitable installation equipment to prevent cutting and abrasion of conduits and wire during the pulling of feeders. Use lubricant and installation procedure as recommended by the cable manufacturer.

3. Pulling tension shall not exceed manufacturer’s recommendations. For conduit runs with three bends, and cable sized larger than 2 AWG, provide the Engineer with cable pulling calculations prior to making the pull.

4. Provide masking or other means to prevent obliteration of cable identifications when solid color coating or colored tracers are used.

5. Multiple cables to be installed in a single conduit shall be pulled together.

G. Splices in power feeders are not allowed unless approved prior to installation and accepted by the District. Splices are permitted only where required to circuit specific devices on shared circuits.

H. Power and Control Cable Installation in Manholes and Pull boxes: Cables shall be routed along the manhole or handhole walls providing the longest possible slack. Cables shall be formed closely parallel to the walls, shall not interfere with duct entrances, and shall be supported on brackets and cable insulators, spaced at a maximum of 4 feet. In existing manholes and handholes where new ducts are to be terminated or where new cables are to be installed, the existing locations of cables, cable supports, and grounding shall be modified as required to provide a properly arranged and supported installation.

3.02 IDENTIFICATION

A. Provide nonmetallic fiberboard or plastic identification tags or pressure sensitive labels designed for fastening to cables, feeders, and power circuits in vaults, pull boxes, manholes, and switchboard rooms, and at all terminations of cable or wire.

B. Stamp or print tags or labels to correspond with markings on the Contract Drawings, or mark so that feeder or cable may be readily identified.

C. If suspended type identification tags are provided, attach the tags to slip free plastic cable lacing units or to nylon bundling straps.

D. Provide wire labels at both ends of all conductors terminated inside panels, pull boxes and hand holes. The wire labels shall be self-laminating, shrink type, wire marker labels which are resistant to oil, water and solvents. The wire identification shall include the identification indicated on the manufacturer’s wiring diagram and/or the circuit number.

3.03 FIELD TESTING

A. Insulation Resistance Test: Insulation resistance test shall be measured on all cables between conductor to grounded shield and shield to ground in accordance with NETA ATS Standard. Insulation resistance shall not be less than 100 Megohms per NETA Standard Table 100.1 for 1000V DC. Cable manufacturers recommended method and values shall be applied.

1. The test shall be made after cable installation, but before splicing or terminating.

2. If the splicing or terminating is not performed immediately after cable installation, second insulation resistance test shall be made just before splicing or terminating.

3. Each cable installation shall be tested after all splices and terminations are complete. No equipment shall be connected to the cable system during tests.

B. Cable Failure: If any field tests fail, the Contractor shall correct deficiency and retest. If the test fails again, the Contractor shall replace the entire cable segment at no additional cost to the District.

END OF SECTION 26 05 24

SECTION 26 05 26

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Grounding and bonding equipment.

B. Grounding rods.

C. Bare conductors.

D. Bus bar.

E. Single conductor insulated wire.

F. Terminal lugs.

G. Jumpers.

H. BART Electrical Substations.
(Definition: Where utility such as PG&E input voltages converted to BART standard voltages through BART transformer)

I. This Section does not cover Traction Power Substations.

1.02 RELATED SECTIONS

A. Section 20 70 26, Common Materials and Methods for Electrical Systems

B. Section 26 05 24, Low Voltage Wires and Cables

C. Section 26 42 00, Cathodic Protection

D. Section 34 21 60, Grounding and Bonding for Traction Power Facilities

E. Chain Link Fence, Sheet 1 of 2, Standard Drawing CS01

F. Chain Link Fence, Sheet 2 of 2, Standard Drawing CS01A

G. Grounding Details – 1,Standard Drawing ES84

H. Grounding Details – 2, Standard Drawing ES85

I. Fence Grounding, Standard Drawing ES86

J. Train Control and Communication Cabinets Power and Grounding Requirements, Standard Drawing K001

K. Automatic Electronic Identification (AEI) Layout and Installation Details, Standard Drawing K002

L. Single Lens Fixed Signal, Installation Details Sheet 1 of 2, Standard Drawing NS27

M. Single Lens Fixed Signal, Installation Details Sheet 2 of 2, Standard Drawing NS28

N. Grounding Requirements Train Control Rooms, Standard Drawing NS67

O. Grounding Requirements Train Control House/Rooms, Standard Drawing NS69

P. Grounding Details of Way Side Equipment Sheet 1 of 2, Standard Drawing NS71

Q. Grounding Details of Way Side Equipment Sheet 2 of 2, Standard Drawing NS72

R. Cable Tray Section and Details, Standard Drawing NS87

S. Grounding Details Sheet 1 of 2, Standard Drawing TPS84

T. Grounding Details Sheet 2 of 2, Standard Drawing TPS85

1.03 MEASUREMENT AND PAYMENT

A. Separate measurement and payment will not be made for the Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the Bid Schedule of the Bid Form, or incidental to the Work of the Contract.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM B3 — Standard Specification for Soft or Annealed Copper Wire
2. ASTM B187/ B187M — Standard Specification for Copper, Bus Bar, Rod, and Shapes and General Purpose Rod, Bar, and Shapes

B. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE 80 — IEEE Guide for Safety in AC Substation Grounding
2. IEEE 81 — IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System
3. IEEE 142 — IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems
4. IEEE 837 — Standard for Qualifying Permanent Connections Used in Substation Grounding

C. Underwriters Laboratories Inc. (UL):

1. UL 467 Standard for Safety Grounding and Bonding Equipment

D. California Code of Regulations:

1. Title 24, Part 3 California Electrical Code

E. National Fire Protection Association (NFPA):

1. NFPA 70 National Electrical Code

2. NFPA 780 Standard for the Installation of Lightning Protection Systems.

1.05 REGULATORY REQUIREMENTS

A. Refer to Section 20 70 26, Common Materials and Methods for Electrical Systems, for requirements.

B. Refer to Section 01 45 24, Testing Program Requirements, for requirements.

C. Refer to Criteria Electrical, Stations and Wayside Systems Structures for Grounding and Electrical Isolation Requirements.

1.06 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings:

1. Submit Shop Drawings showing locations of ground rods, grounding connections, locations of embedded and buried grounding conductors, and locations of stubouts and pigtails for future connections to the grounding system by others. Drawings shall also indicate locations of test points to measure grounding resistance.

2. Submit Shop Drawings showing electrical systems and equipment grounding and bonding connection schematic diagrams.

C. Submit grounding design calculations to meet the requirement of Article 2.02 herein.

D. Product Data: Submit manufacturers' product data of manufactured materials.

E. Test Reports: Submit copies of certified test reports of grounding resistance tests, including method of measurement.

1.07 DELIVERY, STORAGE AND HANDLING

A. Provide marking on wire and cable in accordance with applicable standards. Each item shall be UL-labeled.

B. Ship each item of equipment and materials securely wrapped, packaged, and labeled for safe handling in shipment and to avoid damage.

C. Store equipment and materials in secure and dry storage facility.

PART 2 – PRODUCTS

2.01 EQUIPMENT AND MATERIALS

A. Grounding and Bonding Equipment: Conform to UL 467 and the additional requirements specified herein.

B. Ground Rods: Medium carbon steel core, copper-clad by the molten weld casting process, size of one inch diameter by ten feet long or as indicated, UL listed.

C. Bare Conductors: ASTM B3, Class B stranded, annealed copper conductor, unless otherwise indicated, size as indicated.

D. Bus Bar: ASTM B187/B187M, minimum 98 percent conductivity copper, size as indicated.

E. Single Conductor Insulated Wire: Refer to Section 26 05 24, Low Voltage Wires and Cables. Use insulated ground wire for grounding communication and train control systems.

F. Terminal Lugs: Refer to Section 20 70 26, Common Materials and Methods for Electrical Systems.

G. Jumpers: Tin plated copper, braided, flexible jumper.

2.02 GROUNDING DESIGN

A. Unless otherwise indicated, total ground resistance shall not exceed 5 ohms.

B. In train control room the resistance from the equipment rack to ground plate and from wayside devices to system ground shall not exceed 0.5 ohms.

C. BART electrical substations ground resistance shall not exceed 1 ohm.

D. For traction power grounding requirements, refer to Section 34 21 60, Grounding and Bonding for Traction Power Facilities.

PART 3 – EXECUTION

3.01 INSTALLATION OF GROUNDING SYSTEM

A. Ground Connections:

1. Provide exothermically welded or compression-type terminal lugs for buried or embedded connections using materials qualified in accordance with IEEE 837. Bolted connections shall not be buried or embedded. For compression-type connectors, the tool for crimping shall emboss the die index number into the connector as the crimp is completed. Each compression-type connector shall have an inspection port for use in checking proper conductor insertion.

2. Provide a separate, insulated, equipment-grounding conductor in feeder and branch circuits. Terminate each end on a grounding lug, bus, or bushing.

3. All connections shall be made in accordance with the manufacturer's requirements. All connections shall be cleaned and coated with a bitumastic epoxy before backfilling.

4. Above ground connections shall be made using materials qualified in accordance with IEEE 837. All connections shall be made in accordance with the California Electrical Code and the manufacturer's recommendations.

5. Provide continuous ground conductor or splice using connections qualified in accordance with IEEE 837. All splice connections shall be made in accordance with the manufacturer's requirements.

6. Connect the bus bar to station ground system as indicated. Provide waterstops on ground cable risers, where the risers enter the structure.

B. Ground Rods:

1. Bury ground rods vertically with rod top a minimum of two feet below grade as indicated. Use ground rod as indicated for main grounding system. If extensive rock formation is encountered, relocate ground rods to a new location as approved by the Engineer.

2. Interconnect ground rods with minimum 250 kcmil stranded bare copper cable or as indicated.

3. Ground the frames of motors larger than 25 hp by a ground conductor carried in the power conduit. Provide a ground conductor sized in accordance with the California Electrical Code.

4. Ground the non current carrying metal enclosures of transformers with a conductor sized as indicated or as required by the California Electrical Code.

5. To minimize interference between adjacent rods, the minimum inter-rod distance shall not be less than two rod lengths.

C. Grounding Wires: All grounding wires shall be as indicated and sized to provide adequate conduction path for all possible faults and electrical interference currents.

D. Grounding Requirements: Provide system and equipment grounding as indicated. Ground metallic conduits, raceways, under-floor ducts, cable trays, boxes, cabinets, exposed expansion joints, lighting fixtures, and receptacles in accordance with the California Electrical Code.

3.02 FIELD QUALITY CONTROL

A. Ground Resistance:

1. Test the grounding system by the fall of potential method under the observation of the Engineer. Ground resistance measurement test shall be made in normally dry conditions not less than 48 hours after the last rainfall. If the test is influenced by nearby ground grid, then the test shall be repeated by locating reference electrode to a longer distance until interference in minimized.

2. Each ground rod shall be tested individually per latest NFPA 70 requirements before connecting them together to make grid. Grid ground resistance shall be tested to verify it meets the grounding requirements.

3. Unless otherwise indicated, demonstrate that total ground resistance does not exceed 5 ohms.

4. The ground resistance shall not exceed 0.5 ohms as measured from equipment racks to ground plate in train control rooms and from wayside devices to system ground bus or ground rod connection.

5. The ground resistance shall not exceed 1 ohm in BART electrical substations.

6. To meet these resistance requirements, bury additional ground rods or use electrolytic grounding electrodes, or soldier piles as grounding conductors.

B. Ground System Continuity: Test equipment enclosures, conduit, raceways, exposed expansion joints, lighting fixtures, receptacles, light standards, and metal fencing for continuity to the ground system.

END OF SECTION 26 05 26

SECTION 26 05 70

ELECTRICAL CABINETS AND ENCLOSURES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Enclosures.

B. Auxillary devices.

C. Terminal strips.

D. Nameplates.

1.02 RELATED SECTIONS

A. Control station, panel, and interface cabinet requirements specified in other Sections of these Specifications shall apply for the equipment covered in those Sections.

B. Section 20 50 13, Raceways for Facility Services

C. Section 26 05 24, Low Voltage Wires and Cables

D. Section 26 05 26, Grounding and Bonding for Electrical Systems

1.03 MEASUREMENT AND PAYMENT

A. General: Electrical cabinets and enclosures, as specified herein, will not be measured separately for payment but will be paid for as part of the Contract lump sum price for the related item of work as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. National Electrical Manufacturers Association (NEMA):

1. NEMA ICS 2 Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 Volts

B. Underwriters Laboratories, Inc. (UL)

C. California Code of Regulations (CCR):

1. Title 24, Part 2 California Building Code

2. Title 24, Part 3 California Electrical Code

1.05 REGULATORY REQUIREMENTS

A. Refer to Section 20 70 26, Common Materials and Methods for Electrical Systems, for requirements

1.06 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit Shop Drawings showing materials and methods of construction, door arrangement, conduit hub and knockout locations, complete internal wiring diagrams, mounting locations and supports for equipment mounted in the panels and cabinets, terminal strip designations, and wire numbers.

C. Product Data: Submit manufacturer's product data for manufactured items as follows:

1. Manufacturer's model number or item identification;

2. UL listing and rating;

3. Critical dimensions and mounting arrangement; and

4. Complete replacement parts list.

D. Test Reports: Submit certified test reports of electrical continuity, insulation, and ground continuity tests performed on installed products.

1.07 QUALITY ASSURANCE

A. Select a manufacturer who has been regularly engaged in the manufacture of similar equipment and has met all UL requirements.

B. Conform with applicable requirements of the California Electrical Code.

C. Components of the same type, size, rating, functional characteristics, and manufacture shall be interchangeable.

D. Controls and auxiliary devices shall be tested and certified in accordance with NEMA ICS 2. Certificate of compliance shall be submitted before the assembled equipment is shipped.

1.08 DELIVERY, STORAGE AND HANDLING

A. Provide marking on each control station, auxiliary control panel, and interface cabinet in accordance with the referenced standard.

B. Ship each unit securely wrapped, packaged, and labeled for safe handling in shipment and to avoid damage or distortion.

C. Store control stations, auxiliary control panels, and interface cabinets in secure and dry storage facility.

PART 2 – PRODUCTS

2.01 EQUIPMENT

A. Enclosure: NEMA 12 or as otherwise indicated.

B. Auxiliary Devices:

1. Provide devices of heavy-duty oil-tight construction. Indicator lights shall be transformer type, 120 V AC, 60 Hz, with 50,000 hour lamp life.

2. Auxiliary devices to be installed at each unit shall be standard products and shall be wired in accordance with control diagrams as indicated. Provide heavy-duty type relay, with a contact rating of 20 A at 120 V AC, operating satisfactorily at a temperature of 120 degrees Fahrenheit. Relay characteristics, including inrush current rating, shall be identified on the Shop Drawings.

C. Fabrication: Local control stations, auxiliary control panels, and interface terminal cabinets shall be fabricated and wired complete.

D. Terminal Strips: Channel mounted, snap-fit terminal blocks for 600 V service, molded, high impact strength, strap screw type for 22 AWG through 10 AWG. Terminals shall be at 3/8 inch centers.

E. Nameplates: Provide nameplates showing equipment number. Nameplates shall conform to the requirements of Section 20 70 26, Common Materials and Methods for Electrical Systems.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Embed structural steel or cast-iron sills in concrete for anchoring control stations.

B. Install local control stations, auxiliary control panels, and interface terminal cabinets as indicated and as recommended by the manufacturer, and provide seismic supports and restraints in accordance with applicable requirements of the California Building Code and the California Electrical Code.

C. Install conduit in accordance with requirements of Section 20 50 13, Raceways for Facility Services.

D. Connect power cables and control wires as indicated, and in accordance with Section 26 05 24, Low Voltage Wires and Cables, and Section 20 70 26, Common Materials and Methods for Electrical Systems.

E. Ground local control stations, auxiliary control panels, and interface cabinets in accordance with Section 26 05 26, Grounding and Bonding for Electrical Systems.

3.02 TESTS

A. Perform the following tests, under the observation of the Engineer, and submit certified reports of all tests performed. Furnish equipment and instruments required to perform the tests.

1. Test circuits for connections in accordance with accepted wiring diagrams.

2. Test that insulation resistance to ground of non-grounded conductor is a minimum of ten mega-ohms.

3. Test equipment enclosures for continuity to the grounding system.

4. Test operation of circuits and controls. When testing, operate each control a minimum of ten times and each circuit continuously for a minimum of 1/2 hour.

5. When testing the interface terminal cabinet, provide temporary switches, pilot lights, and relays for remote control and monitoring. Connect these devices to the opposite side of the terminal blocks. Remove upon completion of the tests.

END OF SECTION 26 05 70

SECTION 26 09 26

LIGHTING CONTROL SYSTEM

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Lighting control system requirements.

1.02 RELATED SECTIONS

A. Section 20 30 14, Seismic Performance Requirements for Equipment

B. Section 20 70 26, Common Materials and Methods for Electrical Systems

C. Section 26 05 24, Low Voltage Wires and Cables

D. Section 26 24 24, Circuit Breaker and Panelboards

E. Section 26 50 00, Lighting

F. Section 27 13 01, Communication Cables and Related Equipment

G. Standard Drawing ES87, Typical Lighting Control Systems

H. Standard Drawing ES88, Summary Table of Lighting Control Requirements

1.03 MEASUREMENT AND PAYMENT

A. General: Lighting control system, as specified herein, will not be measured separately for payment but will be paid for as part of the Contract lump-sum price for Electrical Work as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE C62.41 — IEEE Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits

B. California Code of Regulations (CCR):

1. Title 24 — Building Energy Efficiency Standards

C. Illuminating Engineering Society of North America (IES):

1. IES Lighting Handbook, Reference and Application

D. National Electric Manufacturing Agency (NEMA):

1. NEMA 250 — Enclosure for Electrical Equipment (1000 Volts Maximum)
2. NEMA PB 1 — Panelboards
3. NEMA PB 1.1 — General Instructions for Proper Handling, Installation, Operation, and Maintenance of Panelboards Rated 600 Volts or less

E. National Fire Protection Association (NFPA):

1. NFPA 70 National Electrical Code
2. NFPA 101 Life Safety Code

F. Underwriters Laboratories Inc. (UL):

1. UL 50 Standard for Safety Enclosures for Electrical Equipment, Non-environmental Considerations
2. UL 67 Standard for Safety Panelboard
3. UL 916 Standards for Safety Energy Management Equipment
4. UL 924 Standards for Emergency Lighting and Power Equipment

G. International Organization for Standardization (ISO):

1. ISO 9001 Quality Management Systems

1.05 SUBMITTALS

A. Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Submit product data including the following:

1. Catalog sheets and specifications
2. Ratings, configurations, wiring diagrams, dimensions, service conditions, options, and features

C. Submit shop drawings including the following:

1. Single line, schematic, block, and wiring diagrams
2. Equipment layout of lighting control system components
3. Plan view details and component topologies
4. Photometric drawings and network riser diagrams
5. Hard copy of lighting control programming, program flow chart, and time schedule matrix

D. Installation procedures: Include tools and materials list, mounting templates, and dimensions.

E. Submit test reports including the following:

1. Certified test reports of factory and field tests performed
2. Title 24 Acceptance Testing Documentation in accordance to Title 24, Part 6
3. Seismic analysis report

F. Software: Include copy of lighting control software on USB drive with user manual.

G. Manufacturer's certificates: Include certificate ensuring products meet or exceed specified requirements.

H. Submit the operation and maintenance manual, in accordance with Section 01 78 23, Operations and Maintenance Data, including the submittal items mentioned above and the following:

1. Sequence of operation identifying control operation for each room or space
2. Preventive maintenance procedure
3. Spare parts list and ordering form
4. Troubleshooting guide for common issues

1.06 QUALITY ASSURANCE

A. Manufacturer requirements: The manufacturer of the equipment shall have a minimum of five years manufacturing experience and be the manufacturer of the major components within the assembly.

B. Manufacturer's Certification: A qualified factory-trained manufacturer's representative shall certify in writing that the equipment has been installed, adjusted and tested in accordance with the manufacturer's recommendations. The Contractor shall provide three copies of the manufacturer's representative's certification.

C. Installer requirements: The installer shall be a certified lighting control professional or technician with experience performing the Work of this section.

D. Performance requirements: System components shall be manufactured, assembled, and installed to maintain performance criteria stated by the manufacturer that is free from defects, damage, or failure.

E. Code and certification requirements:

1. System components shall be UL listed and certified.
2. Installed system components shall comply with the latest National Electrical Code (NEC).
3. The manufacturer shall be ISO 9001 and Restriction of Hazardous Substances Directive (RoHS) certified.

F. Coordination requirements: The lighting control system shall be comprised of non-proprietary hardware and software and shall be capable of integrating with existing lighting control systems.

G. Seismic requirements: Provide submittals in accordance with Section 20 30 14, Seismic Performance Requirements for Equipment.

1.07 DELIVERY, HANDLING, AND STORAGE

A. Equipment shall be delivered, handled and stored in accordance with manufacturer's instructions until ready for installation.

1.08 PROJECT CONDITIONS

A. Maintain environmental conditions for temperature, humidity, and ventilation within limits recommended by the manufacturer. Products shall not be installed under environmental conditions outside manufacturer's specifications.

1.09 WARRANTY

A. The manufacturer shall provide a five year warranty beginning after the date of Acceptance, which include repair, parts, labor, travel, and living expenses for the manufacturer's certified technician.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers:

1. Wattstopper
2. Lutron
3. Or equal

2.02 SYSTEM REQUIREMENTS

A. The lighting control system (LCS) shall include hardware, software, control devices, networking devices, and associated items required for complete operation. The LCS shall be configured based on site-specific requirements for normal or emergency use as indicated. Refer to Standard Drawings ES87 and ES88 for typical network lighting control systems and sequence of operation.

B. General Requirements:

1. Input Voltage: 120/277 VAC plus or minus ten percent
2. Input frequency: 60 hertz
3. Enclosure: As indicated
4. LCS configuration: Normal Lighting: Network Based
   Emergency lighting: Relay Bypass Module
5. The LCS shall comply with Title 24, Section 110.9, Mandatory Requirements for lighting control systems, devices and Luminaires.

6. The LCS shall be capable of monitoring and controlling lighting control zones based on time-of-day scheduling, astronomical time, daylight savings, holidays, and support control inputs for photocells, control switches, dimmers, and occupancy sensors.
7. The LCS shall facilitate remote and local configuration, monitoring, reporting for operation of groups, channels, zones, schedules, and general system information of luminaires and devices.
8. The LCS shall be capable of interfacing with existing LCS and equipment on the same network.
9. The emergency LCS shall be fail-safe. In conditions where failure is detected within the system, functional luminaires will bypass ON, regardless of pre-programmed operating conditions.
10. Scheduled events for time schedules, photocells, and other control devices shall run autonomously.
11. Self-contained emergency lighting control relays shall be UL-924 listed and provide control that is independent of the LCS. Self-contained units shall only be permitted for luminaires in difficult access areas or on switched circuits and shall be equipped with auxiliary contacts for remote testing with a push to test button on the unit for local testing.
12. The LCS shall be equipped with a maintenance test switch to bypass lighting under scheduled sequence of operation to full ON. Surface of enclosure shall be equipped with LED indicators for input power and system bypass indication.
13. The use of wireless based controls is not permitted in passenger stations or areas that may interfere with train control communications operations under 2.4GHz frequency.

C. Network Lighting Control System:

1. Network Manager: The network manager shall locally manage network communications of lighting and devices over RS-485 (MS/TP) via network bridge. The network manager shall include an IP addressable port, Ethernet (TCP/IP), and be compatible with Modbus TCP/IP network protocols for remote management of the system. Access to lighting control settings shall be controlled through log in security with user-defined name and password.
2. Network Bridge: The network bridge shall connect devices under a local network to the network device manager via optically isolated RS-485 (MS/TP) transceiver. The network bridge shall include spare RJ45 ports for communication with daisy chained communication devices as indicated.
3. Area Controller: The area controlled shall be Class 2.0-10V dimming for lighting loads.
4. Control Device: Control devices for automatic or manual control of lighting shall be self-configuration, and digitally addressable.
5. Input Module: Provide input module for conversion of photocell signal or addition of externally mounted manual bypass switch.

6. Handheld Device: The handheld device shall be capable of two-way infrared communications between the LCS and operator with the ability to read and modify parameters for lighting control sequence of operation.
7. Daisy chain connections for network bridge, area controller, control device, and input module, shall utilize manufacturer pre-terminated communication cables that support both power and data. Cables not derived from the manufacturer shall be individually tested and observed by an authorized service representative prior to use.

D. Relay Bypass Module:

1. General Requirements:
   a. Input Voltage: 120/277 Vac plus or minus ten percent
   b. Testing: Push-to-test button
   c. Inputs: Auxiliary contracts
2. The device shall be UL 924 listed, din-rail mounted, equipped with a button for testing emergency lighting circuits, and include auxiliary contacts for receiving remote commands or interfacing with external devices.
3. The relay bypass module shall bypass pre-programmed sequence of operation for designated emergency lighting to full ON upon loss of normal power or activation of the fire alarm system.
4. The relay bypass module shall work in tandem with normal lighting controls for sequence of operations of normal and emergency lighting.
5. The relay bypass module is permissible for use on switched circuits, difficult access areas, or lighting designed for 24-hour operation as indicated on the lighting control sequence of operation.

E. Network:

1. Ethernet (TCP/IP) communication cable shall be CAT 6A type, RJ45 connector, shielded, with drain wire. Refer to Section 27 13 01, Communication Cables and Related Equipment, for details and grounding requirements.
2. The IP addressable, Ethernet (TCP/IP) control and parameters shall be made available locally and remotely with compatibility to Modbus (TCP/IP) protocol.

F. Control Devices:

1. Photocell
   a. Exterior photocells shall be mounted in an area free from obstruction, facing north, with no direct exposure to nighttime illumination.
   b. Interior photocells shall be mounted above existing luminaires and located central to the area requiring control.
   c. The photocell shall include an internal time delay and dead band to preclude cycling of luminaires.

d. The photocell shall be capable of overriding time-of-day, astronomical time schedules due to unforeseen overcast conditions, and in response to parking structure daylighting requirements.

2. Area Control Switch

a. The area control switch shall be single-pole, 20A, 120V, toggle type or user programmable, wall mounted, momentary push-button type, offered in 1 through 8 button configurations, and shall be mounted adjacent to the lighting control panelboard.

b. Area control switches located in spaces accessible to patrons shall be equipped with a lockable, hinged cover plate, in brushed stainless steel finish.

c. Bypass switch: The bypass switch shall allow manual control of overriding existing programmed lighting control functions. Luminaires shall be commanded ON or OFF contingent upon emergency, maintenance, or demand response requirements as indicated.

1) Install bypass switches adjacent to lighting control equipment or enclosure surface, station agent booths, and additional areas as indicated.

2) Bypass switch installed on enclosure surface shall be rotary type, two-position, maintained, 20A. Include adhesive labeling indicating rotary position for auto and bypass modes.

d. Dimmer switch: The dimmer switch shall be compatible with 0-10V dimmable drivers with lighting loads in single or multi-way applications.

3. Occupancy Sensor

a. Occupancy sensors shall be passive infrared (PIR) or dual-technology PIR/Ultrasonic with 360-degree coverage. Utilize multiple segmented lens with internal grooves to eliminate dust and residue build-up.

b. The occupancy sensor shall turn luminaires off or reduce light levels automatically through a time delay when a room or area is vacated.

G. Software:

1. LCS software shall include:

a. Time-of-day, astronomical time, daylight savings, and holiday scheduling

b. Monitoring and control of luminaries and control devices

c. Status indications for alarm conditions

d. Modification of control logic for sequence of operation

e. User interface for local and remote connections.

f. Data logging

2. The software shall be compatible with the latest Windows operation system.

3. Software license encryption through an external device is not permitted.

2.03 FACTORY TESTING

A. The factory service shall provide adequate testing of the supplied equipment and software to ensure that the system performs as intended by the specification.

PART 3 – EXECUTION

3.01 INSTALLATION

A. The Contractor shall furnish, install and terminate conductors and associated conduits external to any factory supplied equipment.

B. Conductors wiring and routing shall be per the manufacturer's recommendations and as shown on the Contract Drawings.

3.02 FIELD QUALITY CONTROL

A. Provide the services of a qualified factory-trained manufacturer's representative to assist the Contractor in starting-up and programming the system for a period of two working days. The manufacturer's representative shall be factory-trained and shall have a thorough knowledge of the software, hardware and system programming.

B. The Contractor shall provide three copies of the manufacturer's field startup.

C. The following system programming shall be provided by the factory trained manufacturer's representative:

1. Assist the owner in developing a practical control scenario for each application
2. Program the owner supplied control scenario
3. Explain the operation of the control program to the owner

D. Verify complete system operation including hardware, software and communication devices.

E. Verify networking performance with interfacing systems by other manufacturers.

3.03 TRAINING

A. See Section 01 79 00, Demonstration and Training, for additional training requirements.

B. Training shall consist of in classroom and on-site training.

C. The training session shall be conducted by a manufacturer's qualified representative. Training program shall include instructions on the control system, programming, and other major components.

D. The training program shall include:

1. System review of system components and their function
2. System review of management software and its function
3. Hands-on training with the lighting controller and related programming devices to develop experience with software and control applications.

END OF SECTION 26 09 26

SECTION 26 24 13

SWITCHBOARDS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Switchboards.

B. Buses.

C. Circuit breakers.

D. Instruments, controls, and accessories.

E. Source quality control.

1.02 MEASUREMENT AND PAYMENT

1. General: Switchboards, as specified herein, will not be measured separately for payment but will be paid for as part of the Contract lump sum price for Electrical Work as indicated in the Bid Schedule of the Bid Form.

1.03 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM A653/A653M Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

B. California Code of Regulations (CCR):

1. Title 24, Part 2 California Building Code

2. Title 24, Part 3 California Electrical Code

C. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE C37 Circuit Breakers, Switchgear, Substations, and Fuses.

2. IEEE C57.13 IEEE Standard Requirements for Instrument Transformers

3. IEEE C37.20.1 Standard for Metal-Enclosed Low-Voltage (1000 Vac and below, 3200 Vdc and below) Power Circuit Breaker Switchgear

4. IEEE C37.13 Low-Voltage AC Power Circuit Breakers Used in Enclosures

5. IEEE C37.17 Trip Systems for Low-Voltage (1000 V and below) AC and General Purpose (1500 V and below) DC Power Circuit Breakers

D. National Electrical Manufacturers Association (NEMA):

1. NEMA PB 2 Deadfront Distribution Switchboards

E. Underwriters Laboratories Inc. (UL):

1. UL 489 UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures

2. UL 891 UL Standard for Safety Switchboards

3. UL 1066 UL Standard for Safety Low-Voltage AC and DC Power Circuit Breakers Used in Enclosures

F. National Fire Protection Association (NFPA):

1. NFPA 70 National Electrical Code

1.04 REGULATORY REQUIREMENTS

A. Refer to Section 20 70 26, Common Materials and Methods for Electrical Systems, for requirements

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

1. Refer to local utility electrical service requirement for service switchgear

B. Product Data: Submit manufacturer’s product data for all manufactured materials and equipment. Submit certified reports of factory tests performed on each switchboard unit.

C. Shop Drawings: Submit detailed Shop Drawings as follows:

1. Master Drawing Index

2. Single line diagrams;

3. Physical arrangement drawings, and weight of equipment and major components;

4. Unit wiring diagrams;

5. Drawings showing space available for conduit entrance and for routing and training of cables. Available space shall take into consideration bending radius requirements of cables;

6. Schematic diagrams for electrically operated equipment;

7. Nameplates Schedule
8. Component List
9. Schematic diagrams and templates if anchoring in concrete is required.
10. Setting diagrams and templates if anchoring in concrete is required;
11. Assembly and erection diagrams if shipped in sections or if any parts are shipped separately and not installed at the factory; and
12. Interconnection diagrams for circuits having externally located instruments, controls, alarms, or similar devices.
13. Assembly rating including:
    a. Short-circuit rating
    b. Voltage
    c. Continuous current rating
14. Major component rating included:
    a. Voltage
    b. Continuous current rating
    c. Interrupting rating
15. Protective Device Time-Current Curves

D. Operation and Maintenance Data: Submit data in accordance with Section 01 78 23, Operation and Maintenance Data, including the following requirements:

1. Description of the switchboard and its components;
2. Manufacturer's operating and maintenance instructions, parts list, illustrations, and diagram for components;
3. Recommended list of spare parts;
4. Wiring diagram;
5. Electrical characteristics of each component including relays or solid state circuitry; and
6. Relay coordination curves.

E. Field Test Reports: Submit certified field test reports verifying compliance with Specification requirements.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Securely wrap, package, and label each unit for safe handling during shipment.

B. Brace and package the equipment for easy and safe handling. Clearly label temporary internal bracing of equipment as “Temporary Bracing: To Be Removed Before Operation.”

C. Use a mechanical impact recorder during shipment, capable of registering maximum acceleration. Submit impact record chart to the Engineer.

D. Store switchboard in secure and dry storage facility.

PART 2 – PRODUCTS

2.01 SWITCHBOARDS

A. Switchboard Requirements

1. Furnish distribution switchboards that are completely metal enclosed, self supporting, dead front, freestanding, circuit-breaker type for indoor service, that comply with NEMA PB 2, the California Electrical Code, and that are UL listed in accordance with UL 891.

2. Furnish the required number of vertical sections bolted together to form a rigid switchboard. Furnish the number, type, and ratings of circuit breakers and protective devices as indicated.

3. Furnish switchboards completely assembled, wired, and tested at the manufacturer’s plant. If approved by the Engineer, switchboards may be broken down into convenient shipping sections subsequent to the completion of the tests. Separate shipping split terminals shall be provided and connections disconnected for shipping shall be properly identified and protected.

4. Switchboards in the same line up fed electrically from different feeders shall have barriers such that a fire caused by an internal fault at one switchboard shall not spread to another switchboard.

B. Ratings: Furnish completed switchboards rated for service on 480 V, three- phase, four-wire power systems. Symmetrical short circuit current ratings, breaker frame sizes, number of poles, trip unit characteristics, instrument ratings, instrument transformer ratings, and control equipment ratings shall be as indicated. Switchboard current ratings shall be based on operations in a 25 degrees C room ambient.

C. Physical Size: Furnish switchboards 90 inches high, and of width and depth adequate to accommodate and connect the equipment. Vertical sections shall be aligned front and rear, and shall be equipped with rear doors.

2.02 BUSES

A. Requirements: Provide silver-plated copper buses of sufficient size to limit the current density to 750 A per square inch cross-section. Brace distribution switchboard buses for the symmetrical fault current indicated.

B. Main Buses: Extend main buses horizontally from the incoming line sections to all distribution sections if indicated on the same line up. Make provision for extending the main buses for future vertical sections. Neutral bus shall be fully rated, and shall be carried by a neutral pole in the automatic transfer switch.

C. Section Buses: Extend section buses vertically from the main bus through each vertical section.

D. Ground Buses: Extend a ground bus through the length of the switchboard and firmly bolt to each vertical section in at least two places. Make provision for connection to the building or station grounding system near each end of the ground bus. Make provision for future extension of the ground bus.

E. Phasing: Phase buses A B C from left to right, top to bottom, and front to rear as viewed from the front of the switchboard.

F. Bus Connections: Bus connections shall be made only by means of machine screws into threaded holes or with through-bolts with washers and nuts. Connections shall be provided with lock washers for mechanical locking.

2.03 CIRCUIT BREAKERS

A. Provide circuit breakers of the draw out mounted, stored energy, electrically operated type, 480 V, three-phase, 60 Hz, in accordance with NEMA PB 2 and UL 891, with the following additional requirements:

1. Rated continuous current: As indicated.

    a. Symmetrical interrupting rating: As indicated.

    b. Maximum of five cycle closing time.

2. Breakers shall be equipped with solid state trip unit with voltage and current sensors as indicated, and as required. and a minimum of seven time/current systems coordination adjustment, including ground fault and under-voltage settings.

3. Insulation rating of plug shall be the same as the breaker rating.

4. Circuit breakers shall be capable of performing 4000 close open cycles at rated load, 80 percent power factor and rated voltage, and 4000 close open cycles at no load without maintenance and replacement of parts.

5. Breakers shall have control power and motor charging device of 120 V ac.

6. Breakers shall be equipped with field replaceable contacts.

B. Molded-Case Circuit Breakers

1. Molded-Case type circuit breakers shall be mechanically operated with over-center toggle.

   a. Rated continuous current: As indicated and as required.

   b. Symmetrical interrupting rating; As indicated, and as required.

   c. Maximum of five cycle closing time.

2. Breakers shall be equipped with a solid-state trip with voltage and current sensors as indicated and as required and time/current system coordination adjustment, including ground fault and under-voltage setting.

3. Insulation rating of plug shall be the same as the breaker rating.

4. Breakers have control power and motor charging device of 120V ac.

2.04 INSTRUMENTS, CONTROLS, AND ACCESSORIES

A. Potential Transformers: IEEE C57.13, wound type with polarity markers, suitable for operating meters and relays, with the following additional requirements:

1. Voltage ratio: 480 V primary to 120 V secondary.

2. Insulation class: 600 V with basic impulse insulation level of 10 kV full wave.

3. Temperature Rise: Maximum allowable temperature rise shall not exceed 55 degrees Celsius under continuous full load above an average ambient temperature of 25 degrees Celsius.

   a. By winding resistance: 30 degrees Celsius.

   b. By hottest spot in winding: 40 degrees Celsius.

B. Current Transformers:

1. Provide current transformers in a separate compartment isolated from the meter section. Provide metallic shielding to protect current transformers and secondary wiring from induced voltages and to minimize the possibility of insulation failure.

2. Current Transformers shall be bushing or epoxy encapsulated wound type. Secondary terminal blocks shall have covers with integral shorting bars. Secondary wiring shall be connected to readily identifiable terminal block points in the control compartment. Terminal block points shall have integral shorting bars for the current transformer leads.

3. Provide current transformers capable of withstanding thermal and magnetic stresses from the flow of the interrupting and momentary currents of the circuit breakers. Current transformers shall have a mounting frame bolted securely to the switchgear frame. Current transformers shall comply with IEEE C57.13

requirements for relaying accuracy classification under the burdens imposed by the devices specified or implied herein.

C. Meters:

1. Type: IEC 60051, square, taut band, transformer rated, ironvane.

2. Dial: Approximately 4-1/2 inches square, graduated from zero to full range with black figures on white background.

3. Voltmeter rating: 600 V. Ammeter rating: 125 percent of circuit rating, or as indicated.

4. Accuracy Class: One percent of full scale.

D. Relays:

1. Provide one lock out relay for preventing the breaker to re-close after abnormal conditions, except under-voltage.

2. Provide one time delay relay, adjustable from 0 to 6 seconds, for use with under-voltage relay.

E. Control Switches:

1. Provide control switch as required and indicated.

2. Provide relay test switch.

3. Provide manual pushbutton at the front of breaker housing for testing breaker.

F. Control and Instrument Wiring: Provide factory-installed wiring in accordance with the following requirements:

1. Wire: Provide type SIS tinned copper wire not smaller than 14 AWG. Class D stranded wire, not smaller than 12 AWG, shall be used for wiring across hinged joints.

2. Wire Terminals: Tinned copper ring compression terminals with insulated sleeve installed in accordance with the manufacturer’s requirements.

3. Terminal Blocks: Provide washerhead screws suitable for ring compression terminals with insulated sleeve. Provide a minimum of 10 percent spare terminals.

4. Position Switch and Auxiliary Contacts: Provide position switch and breaker auxiliary contacts as indicated.

5. Wire Connections: Controls, relays, and metering circuit terminals requiring external connections shall be wired to accessible terminal blocks. Interconnecting wires terminated on terminal blocks shall be provided in each cubicle.

6. Wire Identification: Each wire shall be provided with plastic strip, attached adjacent to terminal connection, marked with the number indicated on the wiring diagrams, and positioned with the label facing out for ease of identification.

G. Fuses: Provide current limiting fuse in each control circuit.

H. Enclosure: Freestanding type, designed for group assembly to be part of complete indoor ac distribution, with the following additional requirements:

1. Enclosure shall be reinforced with adequate steel framework to form a rigid structure with a smooth outer surface free from burrs, ridges, and other blemishes.

2. Enclosure shall be fabricated from zinc coated steel sheet conforming to ASTM A653/A653M, zinc coating designation G90.

3. Enclosure metallic surfaces shall be thoroughly cleaned, degreased, treated with hot phosphate chemical bath, primed with corrosion inhibiting undercoat primer, and painted with finish coat of heavy-duty, industrial-grade, polyurethane enamel, in standard color as selected by the Engineer.

I. Automatic Transfer Switch: Provide automatic transfer switch as required by Section 26 32 13, Engine Generators.

J. Nameplates: Provide nameplates on each switchboard assembly, individual cabinets, and internal components including relays, switches, lights, and other devices. Nameplates shall conform to the requirements of Section 20 70 26, Common Materials and Methods for Electrical Systems

K. Space Heater: Provide a thermostatically controlled space heater having capacity sufficient to maintain interior temperature above dew point in each cubicle. Space heater rated voltages shall be as follows:

1. Heaters 1.8 kW and over: 480 V, three phase.

2. Up to 1.8 kW: 208 V, three phase.

3. Up to 200 W: 120 V, single phase.

2.05 SOURCE QUALITY CONTROL

A. In addition to the manufacturer’s standard tests, as a minimum perform the following tests at the manufacturer’s plant:

1. 60 Hz dielectric tests;

2. Mechanical operations tests;

3. Grounding of instruments;

4. Transformer case tests;

5. Electrical operation tests; and

6. Control wiring checks.

2.06 COMMUNICATION CAPABILITIES

A. The transfer switch shall be capable of being connected in any of the following network configurations. Interactive Windows(tm) software developed for ATS applications shall be available. The software shall monitor, allow alteration of values, and provide system diagnostics. All values and ATS indications shall be available through the networks.

B. Point-to-Point Connectivity: It shall be possible to connect the ATS directly to a personal computer in the following ways:

1. Local Connection - Maximum cable length 50 feet (15 meters) using RS232.

C. A local area network shall be capable of addressing and interfacing with up to 30 control modules.

D. The communication cable shall run in separate conduit.

PART 3 – EXECUTION

3.01 INSTALLATION REQUIREMENTS

A. Install, wire, and connect switchboards ready for operation in accordance with these Specifications, the manufacturer’s installation instructions, and as indicated.

3.02 WIRING AND CONDUIT WORK

A. Refer to Section 20 70 26, Common Materials and Methods for Electrical Systems, Section 20 50 13, Raceways for Facility Services, and Section 26 05 24, Low Voltage Wires and Cables.

3.03 GROUNDING

A. Refer to Section 26 05 26, Grounding and Bonding for Electrical Systems.

3.04 SWITCHBOARD INSTALLATION

A. Install switchboards in the locations indicated, secure, plumb and level, and align with related adjoining work. The switchboard anchorage and installation shall conform with California Building Code seismic-restraint requirements. Install switchboard on a 4-inch-high concrete pad with leveling channels.

B. Provide anchor bolts and anchorage items as required, and field check to ensure proper alignment and location. Provide templates, layout drawings, and supervision

at the jobsite to ensure correct placing of anchorage items in concrete. Check embedded items for correctness of location and detail before concrete is placed.

C. Install supporting members, fastenings, framing, hangers, bracing, brackets, straps, bolts, and angles as required to set and rigidly connect the switchboard.

D. Provide temporary bracing, guys, or other devices as required to accomplish erection and to provide safety and stability until work is in final position and approved.

E. Control erection tolerance requirements so as not to impair the strength, safety, serviceability, and appearance.

F. Exercise special care during construction to avoid overloading any part of the structure. Repair or replace items damaged due to overloading.

3.05 FIELD TOUCH-UP PAINTING

A. After installations are complete, thoroughly clean surfaces where shop paint coating is missing or abraided bare steel, including bolts, nuts, washers and welds, and paint each item with the same paint system as used for shop painting. Provide touch-up painting by approved spray methods or brush where spray-painting is not practical.

3.06 FIELD TESTS

A. Provide equipment for testing power, lighting, and control circuits after installation, including service test kit. Test under the observation of the Engineer, and demonstrate the following attributes:

1. Verify that circuits are connected in accordance with the applicable wiring diagrams.

2. Verify that circuits are continuous and free from short circuits.

3. Verify that the insulation resistance to ground of non-grounded conductors is megger tested to not less than 10 MΩ.

4. Verify that the completed equipment grounding system is megger tested at each service disconnect enclosure ground bar to ensure connection to ground.

5. Verify that circuits are operable. Conduct tests to include operating each control not less than ten times, and the continuous operation of each lighting and power circuit for not less than 1/2 hour.

END OF SECTION 26 24 13

SECTION 26 24 19

MOTOR-CONTROL CENTERS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Motor control centers.

B. Source quality control.

1.02 MEASUREMENT AND PAYMENT

A. General: Motor-control centers, as specified herein, will not be measured separately for payment but will be paid for as part of the Contract lump sum price for Electrical Work as indicated in the Bid Schedule of the Bid Form.

1.03 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM A653/A653M Standard Specification for Steel Sheet, Zinc Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot Dip Process

2. ASTM B187/B187M Standard Specification for Copper, Bus Bar, Rod and Shapes and General Purpose Rod, Bar, and Shapes

3. ASTM D6386 Standard Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Painting

B. Federal Specifications (FS):

1. TT-C-490F Chemical Conversion Coatings and Pretreatments for Metallic Substrates (Base for Organic Coatings)

C. National Electrical Manufacturers Association (NEMA):

1. NEMA ICS 2 Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 Volts

D. National Fire Protection Association (NFPA):

1. NFPA 130 Standard for Fixed Guideway Transit and Passenger Rail Systems

E. Underwriters Laboratories Inc. (UL):

1. UL 845 Standard for Safety Motor-Control Centers

1.04 REGULATORY REQUIREMENTS

A. Refer to Section 20 70 26, Common Materials and Methods for Electrical Systems, for requirements.

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit Shop Drawings and electrical diagrams of equipment and layouts.

C. Product Data: Submit manufacturer's product data of manufactured materials and equipment.

D. Operation and Maintenance Data: Submit maintenance data and operating instructions in accordance with Section 01 78 23, Operation and Maintenance Data, including the following requirements:

1. Description of the equipment and its components;

2. Manufacturer's operating and maintenance instructions, parts list, illustrations, and diagram of components;

3. Recommended list of spare parts; and

4. Wiring diagrams.

E. Test Reports: Submit certified test reports of factory and field tests performed, verifying that performance of equipment meets Specification requirements.

1.06 DELIVERY, STORAGE AND HANDLING

A. Ship each unit securely wrapped, packaged, and labeled for safe handling of shipment and to avoid damage or distortion.

B. Store motor control centers in secure and dry storage facility.

PART 2 – PRODUCTS

2.01 MOTOR CONTROL CENTERS

A. Provide motor control centers conforming to UL 845 and NEMA ICS 2, Class 2, Type B, rated 480 V, three phase, three wire, 60 Hz, totally enclosed, deadfront free standing modular assembly having vertical and horizontal buses, wireways, and compartments equipped with circuit breakers and starters as indicated.

B. Provide nameplate on each motor starter and control center in accordance with NEMA ICS 2, showing manufacturer's name and brand designation, the referenced standard, type, class, and rating as applicable.

C. Motor control centers shall include the following features, appurtenances, and accessories:

1. Enclosure: NEMA 1 type enclosure with drip shield, modular assembly allowing a maximum of six size one compartment units in one vertical assembly, without structural interference. NEMA 12 type enclosure for damp and dusty locations. Include the following features, appurtenances, and accessories:

   a. Provide each unit compartment with individual door having concealed hinges and unit door mechanically interlocked with unit circuit breaker to prevent opening or closing of door when the circuit breaker is in the ON position. Provide defeater to bypass the interlock.

   b. Equip circuit breaker in each compartment with mechanism and operating handle for operation at front door. Handle shall be lockable at both ON and OFF positions. Provide method so each unit can be padlocked in the test position with the stubs completely withdrawn from the vertical buses.

   c. Provide horizontal wireway with removable coverplate at the top and bottom for wiring between sections, incoming conduit and cable, and control wiring. Provide top trough separated by a barrier from the main horizontal bus.

   d. Provide minimum four-inch wide vertical wireway, with its own door, adjacent to each vertical section and accessible front.

   e. Provide with adequate reinforced steel framework to form a rigid structure with smooth outer surface free from burrs, ridges, and other blemishes.

   f. Provide enclosure fabricated from zinc coated steel sheet conforming to ASTM A653/A653M, zinc coating designation G90, minimum thickness of 14 gage.

   g. Provide painted finish for all ferrous and galvanized metal surfaces as follows: ferrous metal surfaces shall be prepared for painting in accordance with TT-C-490F. Galvanized metal surfaces shall be prepared for painting in accordance with ASTM D6386. After pretreatment, surfaces shall be prime-painted with an approved corrosion-inhibitive metal primer for ferrous or galvanized surfaces, as applicable. Finish coat shall be heavy-duty, industrial-grade polyurethane enamel in color as selected by the Engineer.

2. Horizontal and Vertical Buses: Provide main horizontal buses at the top or center of the structure. Provide vertical buses for feeding power to each compartment in each vertical assembly and securely bolted to the main buses. Buses shall meet the following requirements:

   a. Bus bar shall conform to ASTM B187/B187M, 98 percent conductivity copper, tin plated, fully insulated by extruded sleeve or wound tape.

   b. Each horizontal and vertical bus shall be rated for a minimum of 600 A and 300 A respectively, unless the particular section requires higher rating at

vertical buses due to the arrangement of the horizontal buses. Both vertical and horizontal buses shall have current density not to exceed 1 kA per square inch unless otherwise indicated.

c. Each bus shall be rigidly held by bus supports that have high dielectric qualities, are moisture resistant, non-carbonizing, non-tracking, and have vertical creepage surfaces to prevent faults due to build up of conductive dirt.

d. Both horizontal and vertical buses shall be completely isolated with bus support molding, both between phase to phase and phase to ground. Cutouts at the molding for plug in unit stabs shall be equipped with shutter cover when the unit is in the draw out position, to avoid accidental contact with the vertical buses.

e. Bus assembly shall be braced to withstand short circuit rating as indicated but not less than 42 kA symmetrical (rms).

f. Bus connections shall be made only by means of machine screws into threaded holes or with through-bolts with washers and nuts. Connections shall be provided with lockwashers for mechanical locking.

3. Ground Bus: Provide continuous bare copper ground bus, one-fourth inch by two inches in cross section, provided throughout the length of the control center.

4. Compartments: Compartment arrangement shall be in accordance with the MCC schedules and configurations indicated for the purpose of standardizing compartment numbers at all passenger stations. Provide spaces, if any, at the lowest portion of each section and assign a continued compartment number from the schedule.

   a. Each section shall be designed such that each compartment can be easily modified to accommodate any standardized draw out unit. Provide steel isolation barrier between units with rigid connection to form an effective grounding path to the steel structure.

   b. Provide unit guides in unit compartment for aligning starter stabs.

5. Motor Control Center Units:

   a. Motor control center units with NEMA 4 starter and smaller shall be of the draw-out type. Provide a positive guidance system to assure proper alignment of power stabs in dead front openings to the vertical power bus that shall be isolated from the starter unit.

   b. Design each section such that each unit can be easily modified to accommodate any standardized draw-out unit. Provide steel isolation barrier between compartments with rigid connection to form an effective grounding path to the steel structure.

   c. Components in each draw-out unit shall be the manufacturer’s standard products and readily available for repair and maintenance.

   d. Make plug-in connections by self-aligning, silver-plated stab-type, plug-in fingers designed to tighten onto the vertical bus during high currents.

e. Provide access to each used or spare unit by a separate removable hinged door, attached to the section or to the unit. Provide any unused space that is not suitable for the addition of a draw-out unit with a plain bolted sheet metal cover.

f. Each unit door shall be mechanically interlocked such that the door cannot be opened unintentionally when the external disconnect operator is in the ON position, and so the external disconnect operator cannot be turned to the ON position unintentionally when the door is open. Furnish defeater means to permit trained personnel to bypass the mechanical interlock.

g. Removal of the unit shall require that the door be open and shall not leave the bus exposed that accidental contact with it is possible.

h. Install auxiliary devices such as control power transformers, relays, and instrument transformers in the same space unit as the starter, even though a larger space unit may be required. Acquiring additional space units by means of consolidating components is not acceptable. Mount all components in the vertical position unless specifically designed for another orientation.

i. Provide a door-mounted, sign, laminated plastic with white letters on red background, on each unit in which an external voltage source will be terminated. The sign shall read: “CAUTION THIS UNIT CONTAINS AN EXTERNAL VOLTAGE SOURCE.”

j. Provide a unit device panel assembly, visible from the front of the unit door, with switches and pilot lights as indicated. Devices shall be of the single unit, oil tight, heavy-duty type. Pilot lights shall be transformer type. The device panel may be hinged to the unit allowing the door to dispense with hinged wiring.

k. Circuit Breakers:

   1) Provide a 480V three pole circuit breaker for each unit compartment in accordance with the requirements indicated. Line side of circuit breaker shall have tin plated stab assembly for connecting to the vertical buses in unit compartment.

   2) Circuit breaker compartment, either main or branch breaker, shall be a molded case, thermal magnetic type, with an interrupting capacity as indicated but not less than 25 kA at 480 V ac or 10 kA at 120 V ac. Provide shunt trip attachment where indicated in the MCC schedules. Each breaker shall be equipped with auxiliary contacts for remote monitoring.

   3) Equip circuit breaker in each compartment with mechanism and operating handle for operation at front door. Circuit breaker operating handle positions shall indicate ON, TRIPPED, and OFF. Handle shall be lockable at both ON and OFF positions. Provide method so that each unit can be padlocked in the test position with the stabs completely withdrawn from the vertical buses.

   4) Breakers for a combination starter size, NEMA 4 and smaller, shall be a motor circuit protector type and equipped with current limiter.

Combination starter size NEMA 5 and NEMA 6 shall be reduced voltage autotransformer or solid-state type as indicated.

l. Motor Starters:

1) Provide NEMA ICS 2 motor starter. Motor starters shall be a combination type, full voltage or reduced voltage type, single speed, with nonreversible or reversible operation. Contact rating shall be 480 V ac or 120 V ac as indicated in the motor control center schedules. Motor starter size shall be as indicated, but not smaller than size NEMA 1 for 480 V and size NEMA 0 for 120 V.

2) Equip each motor starter unit with control power transformer, 480 V ac primary and 120 V ac secondary, with two fuses at the primary side and one fuse at the secondary side. Effectively ground the unfused side of the transformer secondary to the frame of the draw-out unit. Wire trip-free manual reset thermal overload relay, one per phase, in the starter.

3) Provide ambient compensated bimetallic overload relays sized for the motor horsepower indicated, based on 1.15 service factor, high efficiency motors in accordance with the requirement of the California Electrical Code.

4) In accordance with the California Electrical Code and NFPA 130 requirements, for motor starters assigned to emergency ventilation fans, provide shorting relay contacts (normally closed) across each control transformer fuse, and overload relay contacts to prevent motor tripping during “Remote Control” Mode of operation. During “Local Control” Mode of operation, the shorting relay contacts across all fuses and overload relay contacts shall open to allow tripping of the motor on overload conditions. Wire normally open contacts of thermal overload relays in parallel for connection to the alarm circuit. Motor protection provided for faults that can destroy the motor in a matter of seconds shall not be bypassed.

5) Provide two NO and two NC auxiliary contacts with provision for future addition of two NC or NO contacts. Auxiliary contacts shall be convertible.

6) Motors larger than 50 hp shall incorporate auto-transfer or solid-state reduced voltage starting as indicated.

m. Terminal Blocks: Each unit shall be equipped with a pull apart type terminal block and arranged such that control wiring shall be de energized when the unit is drawn out from the compartment.

n. Control Wiring:

1) Each compartment shall be factory wired to the terminal block or to other compartments in the same line up. Control wires shall be a minimum of 16 AWG, stranded, thermoplastic insulated wire, rated 105 degrees Celsius.

2) Interconnection wiring between compartments shall be a minimum of 14 AWG, type SIS. Interconnection wiring means cables interconnected to

any compartment in the same line up, even though such compartment may not be connected to the horizontal or vertical bus.

3) Power cable shall be of the same type and rating, black color, and with capacity compatible with the starter or breaker rating.

o. Relay Compartment: Provide draw out type relay compartment without stabs. Relays and wiring devices shall be as indicated. Each relay compartment and 120 V circuit breaker compartment shall be clearly labeled at the draw out unit and shall indicate location of power supply.

p. Nameplates: Provide control center assemblies and individual compartments with nameplates conforming to the requirements of Section 20 70 26, Common Materials and Methods for Electrical Systems

2.02 SOURCE QUALITY CONTROL

A. Perform factory tests under the observation of the Engineer as required to verify proper performance of the equipment.

B. Motor control center section assigned for emergency fans, under platform exhaust fans, and station ventilation fans shall be given a partial seismic test (circuit continuity relay) conforming to NEMA ICS 2.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Embed structural steel or cast iron sills for anchoring motor control centers flush with raised concrete pad as indicated.

B. Install motor control centers as indicated and as recommended by the equipment manufacturer, and provide supports and restraints for seismic loading in accordance with the California Electrical Code.

C. Install conduit in accordance with Section 20 50 13, Raceways for Facility Services.

D. Connect power cable and control wire as indicated, in accordance with Section 26 05 24, Low Voltage Wires and Cables, and Section 20 70 26, Common Materials and Methods for Electrical Systems.

E. Ground motor control centers in accordance with Section 26 05 26, Grounding and Bonding for Electrical Systems.

3.02 FIELD QUALITY CONTROL

A. Perform the following tests and submit certified test reports of all tests. Provide equipment and instruments required to perform the tests.

1. Test circuits for connections in accordance with approved wiring diagrams.

2. Test that insulation resistance to ground of non-grounded conductor is a minimum of ten mega-ohms.

3. Test equipment enclosures for electrical continuity to the grounding system.

4. Test operation of circuits and controls. When testing, operate each control a minimum of ten times and each circuit continuously for a minimum of one-half hour.

END OF SECTION 26 24 19

SECTION 26 24 22

MOTOR STARTERS AND CONTACTORS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Motor starters.

B. Manual starters.

C. Magnetic contactors.

D. Combination starter.

E. Nameplates.

1.02 RELATED SECTIONS

A. Electric motors are specified in Section 20 60 13, Motors for Facility Services.

B. Motor control centers are specified in Section 26 24 19, Motor-Control Centers.

1.03 MEASUREMENT AND PAYMENT

A. General: Motor starters and contactors, as specified herein, will not be measured separately for payment but will be paid for as part of the Contract lump-sum price for Electrical Work as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM A653/A653M Standard Specification for Steel Sheet, Zinc Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot Dip Process

2. ASTM D6386 Standard Practice for Preparation of Zinc (Hot Dip Galvanized) coated Iron and Steel Product and Hardware Surfaces for Painting

B. Federal Specifications (FS):

1. TT-C-490F Chemical Conversion Coatings and Pretreatments for Metallic Substrate (Base for Organic Coatings)

C. National Electrical Manufacturers Association (NEMA):

1. NEMA ICS 2 Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 Volts

1.05 REGULATORY REQUIREMENTS

A. Refer to Section 20 70 26, Common Materials and Methods for Electrical Systems, for requirements

B. California Code of Regulations (CCR):

1. Title 24, Part 2 California Building Code

2. Title 24, Part 3 California Electrical Code

1.06 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit Shop Drawings and electrical diagrams.

C. Product Data: Submit manufacturer's product data of manufactured materials and equipment.

D. Operational and Maintenance Data: Submit maintenance data and operating instructions in accordance with Section 01 78 23, Operation and Maintenance Data, including the following requirements:

1. Description of the equipment and its components;

2. Manufacturer's operating and maintenance instructions, parts list, illustrations, and diagram of components;

3. Recommended list of spare parts; and

4. Wiring diagrams.

E. Test Reports: Submit certified test reports of factory and field tests performed, verifying that performance of equipment meets Specification requirements.

1.07 DELIVERY, STORAGE AND HANDLING

A. Ship each unit securely wrapped, packaged, and labeled for safe handling of shipment and to avoid damage or distortion.

B. Store motor starters and contactors in secure and dry storage facility.

PART 2 – PRODUCTS

2.01 MOTOR STARTERS

A. Provide motor starters meeting requirements of NEMA ICS 2, general purpose Class A, and the following additional requirements:

1. Rating: Continuous current rating suitable for associated motor as indicated. Provide heater sized for motor running protection in accordance with applicable requirements of the California Electrical Code.

2. Type:

   a. Less than 3/4 hp Motor: Starter operable on 120 V, single phase, 60 Hz supply unless otherwise indicated.

   b. 3/4 hp and up to 50 hp Motor: Across the line magnetic starter operable on 480 V, three-phase, 60 Hz supply.

   c. Larger than 50 hp motor: Reduced voltage autotransformer or solid-state type starter.

3. Enclosure:

   a. Type:

      1) For indoor location: NEMA 12.

      2) For outdoor location: NEMA 3R.

   b. Materials: Provide enclosure fabricated from zinc coated steel sheet conforming to ASTM D6386, zinc coating designation G90, minimum thickness of 14 gage.

   c. Finish: Provide painted finish for all ferrous and galvanized metal surfaces as follows: ferrous metal surfaces shall be prepared for painting in accordance with FS TT-C-490. Galvanized metal surfaces shall be prepared for painting in accordance with ASTM D6386. After pretreatment, surfaces shall be prime-painted with an approved corrosion-inhibitive metal primer for ferrous or galvanized surfaces, as applicable. Finish coat shall be a heavy-duty, industrial-grade polyurethane enamel in color as selected by the Engineer.

B. Provide nameplate on each motor starter in accordance with NEMA ICS 2, showing manufacturer's name and brand designation, the referenced standard, type, class, and rating, as applicable.

2.02 MANUAL STARTERS

A. Provide manual starters for fractional horsepower (hp) loads rated at 120 V ac, single phase. Manual starters shall have quick make quick break toggle mechanism, trip free manual reset thermal overload relay, position indicator showing ON, OFF, and TRIPPED positions, and red indicating light showing the CLOSED position.

2.03 MAGNETIC CONTACTORS

A. Provide across-the-line magnetic contactors of reversing or non reversing type as indicated, with the following additional requirements:

1. Provide NEMA size as indicated, not smaller than size NEMA 1 for 480 V and size NEMA 0 for 120 V ac.

2. Provide 480 V primary to 120 V secondary control transformer with one fuse in the secondary circuit.

3. Provide two NO and two NC auxiliary contacts with provision for the future addition of two NO or NC contacts as indicated.

4. Provide indicating lights on each unit enclosure as indicated.

B. Provide auxiliary devices meeting the following requirements:

1. Auxiliary devices to be installed at each contactor enclosure shall be standard products of manufacturers. Provide heavy-duty type relay with contact rating of 20 A at 120 V ac and able to operate satisfactorily at a temperature of 120 degrees F. Identify relay characteristics, including inrush current rating, on Shop Drawings.

2. Terminal blocks used at the contactor shall be mounted in the enclosure. Each terminal block shall be able to accommodate two 14 AWG wires.

3. Control wiring inside the contactor enclosure shall be a minimum of 16 AWG, stranded, thermoplastic insulated wire, rated 105 degrees C, with red color for ac. Power cable shall be of the same type and rating, black color, and with capacity compatible with the contactor or breaker rating.

C. Provide nameplate on each magnetic contactor in accordance with NEMA ICS 2, showing manufacturer’s name and brand designation, the referenced standard, type, class, and rating.

2.04 COMBINATION STARTER

A. Provide combination starter meeting requirements of NEMA ICS 2, rated 480 V, three phase or single phase, 60 Hz, and the following additional requirements:

1. Provide one 480 V, three pole, motor circuit protector type circuit breaker with current limiter, as indicated, with adjustable trip point.

2. Provide externally mounted operating handle with position indicator showing ON, OFF, or TRIPPED condition of the circuit breaker or disconnect switch as applicable. Operating handle shall be interlocked for preventing opening and closing of the door when the circuit breaker or disconnect switch is in the ON position. Provide defeater to bypass the interlock.

3. Provide indicating lights on each unit enclosure as indicated on approved wiring diagrams.

2.05 NAMEPLATES

A. Provide motor starters and contactors with nameplates showing function and number of the motor being controlled. Nameplates shall conform to the requirements of Section 20 70 26, Common Materials and Methods for Electrical Systems.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install motor starters and contactors as indicated and as recommended by the manufacturer. Motor starters shall be properly anchored and the installation shall provide for anchors and restraints for seismic loading in accordance with applicable requirements of the California Building Code and California Electrical Code.

B. Install conduit in accordance with Section 20 50 13, Raceways for Facility Services.

C. Connect power cables and control wires as indicated, in accordance with Section 26 05 24, Low Voltage Wires and Cables, and Section 20 70 26, Common Materials and Methods for Electrical Systems.

D. Ground motor starters and contactors in accordance with Section 26 05 26, Grounding and Bonding for Electrical Systems.

3.02 FIELD QUALITY CONTROL

A. Perform the following tests and submit certified test reports of all tests. Provide all equipment and instruments required to perform the tests.

1. Test circuits for connections in accordance with accepted wiring diagrams.

2. Test that insulation resistance to ground of non-grounded conductor is a minimum of 10 MΩ.

3. Test equipment enclosures for continuity to the grounding system.

4. Test operation of circuits and controls. When testing, operate each control a minimum of ten times and each circuit continuously for a minimum of 1/2 hour.

END OF SECTION 26 24 22

SECTION 26 24 24

CIRCUIT BREAKERS AND PANELBOARDS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Enclosed circuit breakers.

B. Panelboards and load centers.

1.02 RELATED SECTIONS

A. Motor control centers are specified in Section 26 24 19, Motor-Control Centers.

1.03 MEASUREMENT AND PAYMENT

A. General: Circuit breakers and panelboards, as specified herein, will not be measured separately for payment but will be paid for as part of the Contract lump-sum price for Electrical Work as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM B187/B187M Standard Specification for Copper, Bus Bar, Rod, and Shapes and General Purpose Rod, Bar, and Shapes

B. National Electrical Manufacturers Association (NEMA):

1. NEMA AB 1 Molded Case Circuit Breakers
2. NEMA PB 1 Panelboards
3. NEMA PB 1.1 General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or less
4. NEMA PB 1.2 Application Guide for Ground-Fault Protective Devices for Equipment

C. Underwriters Laboratories Inc. (UL):

1. UL 50 Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations
2. UL 67 Standard for Safety Panelboards
3. UL 489 Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breakers Enclosures

D. InterNational Electrical Testing Association (NETA):

1. NETA ATS Acceptance Testing Specifications for Electrical Power Distribution

E. National Fire Protection Association (NFPA):

1. NFPA 70 National Electric Code

2. NFPA 70E Standard for Electrical Safety in Workplace

F. Federal Specifications

1. FS W-C-375 Circuit Breakers, Molded Case, Branch Circuit and Service

2. FS W-P-115 Power Distribution Panel

1.05 REGULATORY REQUIREMENTS

A. Refer to Section 20 70 26, Common Materials and Methods for Electrical Systems, for requirements.

B. California Code of Regulations (CCR):

1. Title 24, Part 2 California Building Code

2. Title 24, Part 3 California Electrical Code

1.06 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

1. Refer to local utility electrical service requirements for meter centers.

B. Product Data: Submit manufacturers' product data for specified equipment and materials. Include the following information for each item:

1. Manufacturer's model number or item identification;

2. UL listing and rating;

3. Critical dimensions and mounting arrangement; and

4. Replacement parts list.

C. Shop Drawings: Submit Shop Drawings and electrical diagrams as follows:

1. Enclosures: Drawings showing materials and methods of construction, door arrangement, conduit hub and knockout locations, and identification of intended panelboard or load center.

2. Circuit Breakers: Drawings showing circuit for which intended, voltage ratings, insulation level, current rating, interrupting ratings, and time-current curves.

3. Panelboards and Load Centers: Drawings showing base material, general arrangement, location, and identification of each circuit breaker and the circuit breaker information specified above, location and identification of terminals, location of barriers, applicable UL 67 information, wiring diagrams, and identification of the enclosure for which intended.

D. Test Reports: Submit copies of certified reports of factory and field tests performed in accordance with the applicable referenced standards and specification requirements.

1.07 QUALITY ASSURANCE

A. Select a manufacturer who has been regularly engaged in the manufacture of similar equipment and has met UL requirements.

B. Conform to UL 489, NEMA PB 1, and California Electrical Code, as applicable.

C. Products shall be tested, approved, and labeled/listed by UL.

D. Electrical equipment and material shall be new and within one year of manufacture, complying with the latest codes and standards. Used, re-built, refurbished and re-manufactured electrical materials shall not be used.

E. Components of the same type, size, rating, functional characteristics, and manufacture shall be interchangeable.

1.08 DELIVERY, STORAGE AND HANDLING

A. Provide markings on each circuit breaker, panelboard, and load center in accordance with the referenced standard. Each item shall be UL labeled.

B. Ship each unit securely wrapped, packaged, and labeled for safe handling in shipment and to avoid damage or distortion.

C. Store circuit breakers, panelboards, and load centers in secure and dry storage facility.

PART 2 – PRODUCTS

2.01 EQUIPMENT

A. Enclosed Circuit Breakers:

1. Provide UL 489, molded case, quick make quick break bolt on type, with thermal magnetic type overload trip, interchangeable unit for frame rated 125 A and above. Breakers shall include the following requirements as indicated:

    a. Number of poles;

    b. Rated voltage and continuous current;

    c. Rated interrupting current; and

    d. Trip setting.

2. Molded Case Protective Devices

    a. Protective devices shall be molded case circuit breakers with inverse time and instantaneous tripping characteristics.

    b. Circuit breakers shall be operated by a toggle-type handle and shall have a quick-make, quick-break over-center switching mechanism that is mechanically trip-free. Automatic tripping of the breaker shall be clearly indicated by the handle position. Contacts shall be non-welding silver alloy and arc extinction shall be accomplished by means of arc chutes.

    c. Circuit breakers shall have a minimum symmetrical interrupting capacity as indicated.

    d. Circuit breakers 15 to 100 ampere frame shall be provided with fixed thermal-magnetic trip units.

    e. Circuit breakers 225 ampere frame and above shall be provided with field-changeable, field-adjustable thermal-magnetic trip units with inverse time-current characteristics. Trip mechanisms shall be provided with instantaneous, long time pickup, and short time pickup.

    f. Circuit breakers 400 ampere frame and above shall be provided with microprocessor-based RMS sensing trip units with features noted on the Contract Drawings. Trip mechanisms shall be provided with instantaneous, long time pickup, long time delay, short time pickup, short time delay, I2t function, ground fault pickup, ground fault delay.

    g. Circuit breakers for HVAC and refrigeration unit equipment shall be listed by UL as Type HACR.

3. When circuit breakers are located in spaces other than the main electrical distribution system equipment rooms and used to protect conductors serving emergency equipment motors (such as fans, dampers, and pumps), emergency lighting, and communications equipment, they shall not be tripped by the thermal element. Thermal element contact shall be used to indicate an alarm condition.

    a. Circuit breakers for tunnel lighting and power panel shall have auxiliary contacts. These contacts shall be paralleled to provide a common “panel trouble” alarm locally and to Central Control.

B. Panelboards and Load Centers: NEMA PB 1 or UL 67, with the following additional requirements:

1. Circuit Breakers

    a. Molded Case Circuit Breakers: NEMA AB 1, FS W-C-375; Provide bolt-on type circuit breakers with integral thermal and instantaneous magnetic trip in each pole (common trip type). Provide circuit breakers, UL listed as Type HACR, for air conditioning equipment branch circuits. Provide circuit breakers, UL listed as Type SWD, for lighting circuits. Provide UL Class A ground fault interrupter circuit breakers where specified on panelboard schedules as indicated.

    b. Trip Unit:

        1) Instantaneous magnetic trips shall be accessible and adjustable from the front of the breaker on frame size 100 amperes.

        2) Trip units shall be interchangeable and adjustable for trip pick up and delay settings on frame size 225 amperes.

        3) Breakers sized 400 amperes and higher shall be equipped with solid state trip units with long-time, short-time, instantaneous, and ground fault (LSIG) tripping characteristics.

    c. Breakers shall be rigidly mounted, separately removable and independent of trim plates for their support. Breakers shall be bolt on type.

    d. Breakers shall be industrial grade with a minimum pole width of 1-inch (25.4 mm) and a minimum height of 5-1/2-inches (139.7 mm). Miniature circuit breakers or breakers having a pole width of 1/2-inch are not acceptable.

    e. The minimum symmetrical interrupting rating for molded-case circuit breakers shall be as specified on the panelboard schedule as indicated. Series rated breakers are not acceptable.

2. Enclosure: NEMA or UL rated based on site conditions fabricated from galvanized steel, stainless steel, or other corrosion-resistant treated metal such as primed and painted steel, surface mounted unless otherwise indicated, tamperproof, with the following additional requirements:

    a. Gutter size:

Main Bus Rating Amperes	End Gutter Size (Inches)	Side Gutter Size (Inches)
225 and below	6	5
400 and over	8	8

    b. Provide interior components mounted on reinforced steel backplate for rigid support and accurate alignment.

    c. Provide device or mechanism for enclosure grounding.

3. Hardware and Trim:

    a. Panelboards shall be designed for surface or flush mounting in unsecured areas as indicated, and shall contain a hinged door fitted with a combination latch and door lock, accommodating a master key. Provide one flat key tumbler cylinder type, nickel plated door lock conforming to the station masterkey system, two keys per lock.

    b. Nameplates or other permanent identification shall be provided for each circuit breaker, which shall mount adjacent to the individual circuit breakers, as required by UL.

    c. Panel schedule with acrylic plastic face, 8-1/2 inches by 11 inches, shall be provided and mounted on the back of the door.

    d. Flush-mounted panelboards shall be provided, with means to plumb and align the front of the panel with respect to the adjacent finished surfaces.

    e. Unless otherwise specified, finish shall be a metallic surface thoroughly cleaned, degreased, primed with an approved corrosion-inhibitive primer, and then finished with heavy-duty, industrial-grade polyurethane enamel.

4. Bus Bars: ASTM B187/B187M, 98 percent conductivity copper, with silver plated contact surface, and the following additional requirements:

    a. Provide neutral bus of the same rating as that of phase bus. Provide neutral bus rating of 200 percent of the phase bus for loads creating harmonics.

    b. Provide main lugs or main circuit breaker of rating as indicated.

    c. Provide a grounding bus.

5. Each panelboard or load center shall have a main circuit breaker with same continuous rating as main bus ampere rating when the panelboard or the load center is located in the space other than that within the sight of the location of the feeder protective device on supply side.

6. Nameplates: Provide nameplates showing panelboard number. Nameplates shall conform to the requirements of Section 20 70 26, Common Materials and Methods for Electrical Systems.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install panelboards and load centers at locations indicated with the top 6 feet, 6 inches above the floor and the bottom not less than 12 inches above the floor, unless specifically indicated otherwise. Use multi-sectional panelboards and load centers to meet these spacings if necessary. Line up tops of trims to present neat appearance.

B. Mount panelboards and load centers in place with front straight and plumb, and anchor in accordance with applicable requirements of the California Building Code.

C. When a feeder serves more than one panelboard or panelboard section, install a separate junction box or provide adequate gutter area for termination of feeders and bus taps.

D. Provide circuit breakers of proper ratings for all branch circuits. Connect branch circuit wires as indicated. Connect neutral wires of branch circuits to the neutral bar of the same panelboard as the branch circuit.

E. Make conduit connections in accordance with Section 20 50 13, Raceways for Facility Services.

F. Make cable connections in accordance with Section 26 05 24, Low Voltage Wires and Cables.

G. Ground panelboards and load centers in accordance with Section 26 05 26, Grounding and Bonding for Electrical Systems.

H. Bus connections shall be made only by means of machine screws into threaded holes, or with through-bolts with washers and nuts. Connections shall be provided with lockwashers for mechanical locking.

3.02 PANEL SCHEDULE INSERT

A. Provide each panelboard and load center with a typewritten circuit directory located on the inside of the enclosure.

B. For each panelboard, include the panel name and schedule. Schedule shall include the following:

1. Panelboard type.

2. Number of phases.

3. Main bus ampacity.
4. Main circuit breaker trip rating.
5. Branch circuit breaker arrangement.
6. Branch circuit breaker trip sizes.
7. Flush or surface mounting.
8. Enclosure type.
9. Circuit load.
10. Location.

3.03 FIELD QUALITY CONTROL

A. Perform the following tests per the NETA procedures under observation of the Engineer. Furnish equipment and instruments required to perform the tests.

1. Test circuits for connections in accordance with the wiring diagram.
2. Perform insulation resistance to ground in accordance with NETA ATS. In absence of manufacturer's published data, use NETA ATS Table 100.1.
3. Test panelboard and load center enclosures for continuity to the grounding system.
4. Test operation of circuits and controls. When testing, operate each control a minimum of ten times and each circuit continuously for a minimum of 1/2-hour.
5. Test that each panel has a balanced load.
6. Maintain a log of all tests.

END OF SECTION 26 24 24

SECTION 26 32 13

ENGINE GENERATORS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Engine-generator system.

B. Automatic transfer switch.

C. Communication capabilities.

D. Fabrication and shop tests.

1.02 RELATED SECTIONS

A. Section 20 30 14, Seismic Performance Requirements for Equipment

B. Section 20 70 26, Common Materials and Methods for Electrical Systems

C. Section 20 72 25, Factory and Field Testing

D. Section 23 13 23, Above Ground Fuel Storage Tanks

E. Section 26 05 26, Grounding and Bonding for Electrical Systems

F. Section 26 24 24, Circuit Breakers and Panelboards

G. Section 26 50 00, Lighting

1.03 MEASUREMENT AND PAYMENT

A. General: Engine generators, as specified herein, will not be measured separately for payment but will be paid for as part of the Contract lump sum price for Electrical Work as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. Bay Area Air Quality Management District (BAAQMD)

B. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE C37.13 Low-Voltage AC Power Circuit Breakers Used in Enclosures

2. IEEE C37.90 Relays and Relay Systems Associated with Electric Power Apparatus

3. IEEE 43 Recommended Practice for Testing Insulation Resistance of Electric Machinery

C. International Organization for Standardization:

1. ISO 3046-4 Reciprocating Internal Combustion Engines – Performance – Part 4: Speed Governing

D. National Electrical Manufacturers Association (NEMA):

1. NEMA ICS 1 Industrial Controls and Systems General Requirements
2. NEMA MG 1 Motors and Generators
3. NEMA MG 2 Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators
4. NEMA PB 2 Deadfront Distribution Switchboards

E. National Fire Protection Association (NFPA):

1. NFPA 30 Flammable and Combustible Liquids Code
2. NFPA 37 Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines
3. NFPA 70 National Electrical Code
4. NFPA 110 Standard for Emergency and Standby Power Systems

F. Society of Automotive Engineers (SAE):

1. SAE J537 Storage Batteries

G. Tubular Exchanger Manufacturers Association (TEMA):

1. TEMA Book of Standards

H. Underwriters Laboratories, Inc. (UL):

1. UL 142 Standard for Safety Steel Aboveground Tanks for Flammable and Combustible Liquids
2. UL 508 Standard for Industrial Control Equipment
3. UL 1008 Standard for Safety Transfer Switch Equipment
4. UL 1236 Standard for Battery Chargers for Charging Engine-Starter Batteries
5. UL 2085 Standard for Safety Protected Aboveground Tanks for Flammable and Combustible Liquids
6. UL 2200 Standard for Safety Stationary Engine Generator Assemblies

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit schematic and interconnection drawings, as follows:

1. Schematic diagrams of the following:

    a. Engine control;

    b. Generator control; and

    c. Automatic engine starting.

2. Point to point wiring diagrams: Wiring shall show site required field wiring terminations.

3. Description of the system operation.

4. Electrical data including short circuit impedances.

5. Exhaust system details.

6. Fuel oil system details. Provide complete piping and instrumentation diagrams (P and ID).

7. Lube oil system detailed flow diagram.

8. Structural calculations and seismic qualification certification according to Contract Specification 20 30 14, Seismic Performance Requirements for Equipment. Submit pertinent data for structural engineering of the base to the concrete pad including weights, points of attachment, and center of gravity shall be included.

9. Outline dimensions and foundation requirements including physical layout and dimensioning with complete section views.

10. Vibration isolation with seismic certification and calculations.

11. Housing elevation, plan, rigging diagram, installation diagrams, and details.

12. Access stair and platform elevation, plan, installation diagrams and details, as required.

13. Sub-base tank details.

14. Aux power panelboards with loads and schedule.

15. For each alarm and status point, provide set point value and range.

16. Underground power cable entry details.

C. Product Data: Submit manufacturer's product data, certificates, and test reports as follows:

1. Specification sheets showing standard and optional accessories to be supplied including but not limited to the following;

   a. Engine-generator

   b. Exhaust silencers

   c. Starting batteries

   d. Battery system including jars and charger

   e. Fuel oil system including primary and secondary fuel filters

   f. Cooling system including air and water side components

   g. All control panels

   h. Housing components and materials

   i. Aux power panelboards

   j. Lube oil heater with thermostat control

2. Performance data, including curve of engine fuel consumption versus kilowatt output at no load, half load, three-quarter load and full load.

3. Engine starting performance.

4. Generator thermal damage curve.

5. Generator circuit breaker time-current curves.

6. Generator capability curve.

7. Air flow calculations.

8. Parts and special tools lists, specifying quantity of each item.

9. Certificates of compliance for specified products.

10. Test reports verifying specified performance requirements for equipment.

D. Factory test script

E. Operation and Maintenance Manual: Refer to Section 01 78 23, Operation and Maintenance Data, for requirements.

F. Sound-Retardant Data: Submit noise control data and vibration isolation instructions. Provide acoustical data for 100 percent loaded generator.

G. The approved permit to operate diesel generator by BAAQMD.

1.06 QUALITY ASSURANCE

A. Equipment shall fit within the space allocated on the Contract Drawing.

B. Assume responsibility for code approvals related to furnished equipment and housing.

C. Wiring and equipment installation shall comply with the requirements of the NEC and requirements of District for access, clearance, material including but not limited to panelboards, circuit breakers, lighting systems, and grounding.

D. Manufacturer's Representative: Furnish the services of a qualified field engineer, experienced in the installation and operation of the type of systems being provided, to supervise the installation, testing, adjustment of the system, and to provide training for District personnel.

E. Manufacturer's Responsibility:

1. The engine-generator set shall be manufactured by a single manufacturer who has been regularly engaged in the production of engine-generator sets for a minimum of 10 years. The generator system described herein, including these components shall be factory built, factory-tested at rated load, starting duty and power factory, and shipped by this single manufacturer, so there is one source of supply and responsibility for guarantee, parts, and service. This manufacturer shall have a local representative in the San Francisco Bay Area who can provide factory-trained servicemen, required stock of replacement parts, and technical assistance.

2. The generator system shall meet requirements of NFPA 110, including design specifications, prototype tests, one-step full load pickup, and installation acceptance.

3. The responsibility for performance to this Section in its entirety shall not be split up among individual Suppliers of components comprising the system, but shall be assumed solely by the engine-generator set manufacturer. Controls shall be the standard of the engine-generator set manufacturer. Control parts shall be identified by parts numbers of this manufacturer and shall have second source listing where applicable. Control systems that are supplied by a vendor and not incorporated within the Shop Drawings of the engine-generator set manufacturer are not acceptable.

1.07 SPARE PARTS LIST

A. Generator manufacturer shall provide a recommended spare parts list.

1.08 WARRANTY

A. The warranty of the engine-generator shall be no less than 24 months after acceptance and must include all costs including repair, labor, travel, and living expenses for the manufacture's service personnel. Provide option for 60 month warranty.

B. Provide individual generator starting batteries with a 12 month full replacement guarantee followed by a 24 month prorated warranty.

C. If required during the warranty period, the engine-generator Supplier shall provide necessary labor, materials, and repair related expenses.

PART 2 – PRODUCTS

2.01 ENGINE-GENERATOR SYSTEM

A. Acceptable manufacturers:

1. Cummins
2. Caterpillar
3. Kohler
4. Or equal

B. General: Engine-generator shall be sized per Contract Drawings. This specification applies to standby and emergency generators.

1. Controller shall be integral part of the engine-generator system. The system shall include necessary accessories to provide a complete and operating system.
2. Engine-generator system shall be capable of operating continuously at rated output in accordance with NEMA MG 1 in ambient temperature range of 0 degrees Celsius to 40 degrees Celsius.
3. The engine-generator shall be a completely self-contained unit, fully assembled and mounted on a common self-supporting base, and shall consist of the following components as a minimum:
    a. Molded case circuit breaker with thermal magnetic trip. Circuit breaker shall be mounted in a NEMA 12 type metal enclosure, unless otherwise specified in the Contract Drawings.
        1) Provide arc flash reduction maintenance mode switch with clear plastic cover, if required by code. Provide blue pilot light indicating maintenance mode is ON and activated. Provide maintenance mode switch with Form C contact for supervision.

b. Control panel in a NEMA 12 type metal enclosure, unless otherwise specified in the Contract Drawings.

c. Starting battery complete with charger, battery rack, battery cables, and charger alarm board for remote indication.

d. Exhaust mufflers rated for residential use.

e. Intake air filters and critical rated intake silencer.

f. Day and main fuel tanks in accordance with Section 23 13 23, Above Ground Fuel Storage Tanks.

g. Engine mounted radiator system, complete with duct flange adapter for connection to wall louver.

h. Auxiliary devices, appurtenances, and equipment required to operate the engine-generator.

4. Engine-generator and fuel tank shall have continuous kilowatt rating as indicated. Ratings shall be 480/277 V, 0.8 power factor, 60 Hz, 3 phase, 4 wire, 60 HZ, 1800 rpm, and shall withstand the ambient temperature range specified herein.

5. Engine-generator shall restore facility power in maximum 10 seconds from utility power failure.

6. Engine-generator shall be vibrationless within the normal operating speed range.

7. Engine-generator shall be mounted on a concrete pad with vibration absorbing isolators as recommended by the generator manufacturer to meet requirements for operation in residential environment.

8. Lifting lugs or angles and jacking pads shall be provided on the self-supporting base, and on each major component of the engine-generator.

9. Outdoor engine-generator shall be enclosed within a sound attenuation, weatherproof enclosure and meet the requirements of NEMA MG 2. The sound power level at rated full load shall not exceed 75 dBA weighted average measured at 23 feet from all sides of the unit.

    a. Provide a minimum of four (4) vapor-tight LED lights ceiling mounted with the enclosure. Lights shall be suitable for operation in site ambient conditions.

    b. Provide two (2) dual head emergency LED lights with a battery backup power supply meeting UL 924, NFPA 101, OSHA illumination standards.

    c. Provide minimum of two (2) convenience receptacles inside the enclosure.

10. The engine generator and the fuel tank shall be mounted on a housekeeping pad integral with existing concrete slab. The concrete slab shall be designed to include proper spill and overflow containment and shall include drainage and treatment of any storm waste water or other fluids that could collect in the containment area. The integreal fuel tank shall comply with UL 2085.

C. Engine

1. The engine shall be four-cycle diesel of the manufacturer's standard design with proven reliability in service. Engine design, materials, and workmanship shall be in accordance with standards referenced in Section 1.04 of this specification and with applicable national, state, and local codes. Engine exhaust emissions shall meet the regulatory requirements of the Bay Area Air Quality Management District and shall be minimum Tier 2 certified.

2. Brake horsepower rating of the engine shall be not less than that necessary to produce continuous rated generator output at rated speed (1800 rpm maximum) and under the specified service conditions. Provide a manufacturer's approved block heater.

3. Each engine shall be provided with at least the minimum equipment required to start and operate the generator. The following components and accessories shall be provided:

    a. All necessary speed, pressure, and temperature sensors and devices for indication, alarm, and safety trip functions.

    b. All flexible connections necessary to isolate the engine from piping, conduit and building.

    c. Manufacturer-supplied block heater shall be hardwired to 208-240VAC to maintain lube oil and jacket water temperatures.

4. The engine shall be equipped with a governor. Speed regulation shall be manually adjustable. Performance of the speed governing system shall be in accordance with the applicable section of ISO 3046-4.

5. The control shall provide visual warnings, shutdowns, and audible indications for conditions specified in NFPA 110, Level 1.

    a. Control switches and relays necessary to start the engine locally or remotely and to stop the engine automatically, locally, or remotely.

    b. Programmable cyclic cranking shall allow at least three crank cycles and 45 seconds of continuous crank time.

6. Jacket cooling water system shall include at least the following for each engine:

    a. Jacket water radiator and cooling fan.

    b. Jacket water pump.

    c. Thermostat valve for automatic temperature control of the jacket water.

    d. Jacket water block heater, with thermostat switched by block heater control circuit.

    e. Valves, piping, and fittings.

7. Engine lubricating system shall include at the least the following for each engine:
    a. Circulating pumps;
    b. Filters and/or strainers;
    c. Lubricating oil cooler;
    d. Lubricating oil pumps, as necessary;
    e. Valves, piping, and fittings;
    f. Control signals for electric motor starter control circuits;
    g. Lubricating oil heater.
8. Fuel oil system equipment shall include at least the following for each engine:
    a. Engine fuel pump designed to transfer the fuel from the adjacent fuel day tank or sub-base tank;
    b. Valves, piping, and fittings;
    c. Filters and strainer; and
    d. Fuel oil meter.
9. Sub-base fuel tank shall have a 24-hour capacity and shall include at least the following for each engine:
    a. Level gauge;
    b. Low-level alarm detector and suitable relay;
    c. Low and high level switches for transfer pump control and inlet control valve;
    d. Couplings for inlet, outlet, vent, and overflow;
    e. Fuel transfer pump to deliver fuel from the fuel storage tank to the day tank. The fuel transfer pump shall deliver 5.0 gpm at 6.0 psi with a suction lift of 7.5 feet;
    f. Refer to Section 23 13 23, Above Ground Fuel Storage Tanks for further requirements.
10. Provide battery rack and cables, capable of supporting the manufacturer's recommended batteries.
11. Provide 12-Volt lead-antimony batteries capable of delivering the manufacturer's recommended minimum cold-cranking current required at 0 degrees Fahrenheit, per SAE J537.

12. Ten-Ampere automatic float and equalize battery charger with plus or minus 1 percent constant voltage regulation from no load to full load over plus or minus 10 percent AC input line variation, current limited during engine cranking and short circuit conditions, temperature compensated for ambient from -30 degrees Celsius to +50 degrees Celsius, five percent accurate voltmeter and ammeter, fused, reverse polarity and transient protected.

13. Engine governor shall be the electronic, solid-state type. Frequency regulation shall be within plus or minus 0.5 percent for any load between 20 and 100 percent and frequency dip during full load application shall not exceed eight cycles per second from rated frequency. Governor components to be provided with the unit shall include: actuator, amplifier, speed sensing, load sensing, burden resistor, and magnetic pickup.

D. Generator

1. The generator shall be of the synchronous, brushless salient pole type in accordance with NEMA MG 1, for a solidly grounded system, with drip proof enclosure.

2. Voltage, frequency, and nameplate kilowatt rating shall be as specified herein.

3. Generator and excitation system shall provide for operation at the overload capability of the engine, at rated power factor, frequency, and voltage. Insulation shall be NEMA Class H. Temperature rise at continuous rating shall not exceed 125 degrees Celsius, above 40 degrees Celsius ambient temperature, and the temperature rise for standby rating shall not exceed NEMA MG 1, requirements for Class H insulation.

4. The exciter-voltage regulator system shall be complete with all components necessary to provide manual voltage control, automatic voltage regulation, automatic field flashing, and positive surge protection for any solid-state components utilized in the system.

5. Stator coils shall be mechanically braced to prevent distortion under short circuit or other transient conditions.

6. Length of leads connecting phase winding to surge protection shall be kept to a minimum. Terminals of surge protection shall be located between feeder cable terminations and phase windings.

7. Accessories shall include the following components:

   a. Slide rails or sole plates if necessary to provide for stator shift.

   b. Surge capacitors for generator protection.

E. Panelboard

1. Provide panelboard within enclosure to feed miscellaneous loads including but not limited to battery charger, heaters, lights, and receptacles. Provide the number of pole breakers as required for the loads plus 20 percent space. Submit calculations and sizing.

F. Control Panel Assembly

1. The control panel assembly shall meet the requirements of UL 508.

2. Provide microprocessor-based controller with monitoring software.

3. Control panel shall consist of individual steel structures, one for each generator bolted together to form a single NEMA 12 type metal enclosed dead front assembly. Control panel shall be mounted 4 feet - 6 inches from center of control panel to floor or an operator platform. Provide three steps or as required galvanized steel hideaway boarding ladder for control panels mounted on operator platform. Access ladder shall not block equipment maintenance.

4. The panel shall contain at least the following devices for remote operation and monitoring of each engine-generator:

   a. Engine controls including manual START-STOP control and governor control and speed adjustment.

   b. Generator controls, including automatic and manual voltage adjustment and generator shutdown and reset switches.

   c. An AUTO-MANUAL-OFF selector switch for manual starting in MANUAL position, and automatic starting in AUTO position, and off in OFF position.

   d. Automatic plant exercise shall be provided to allow the user to choose between 7-day, 14-day, or manual mode to exercise the generator set at a preset time period, and override function to terminate the exercise at any time. The accessories to allow the plant exerciser to run the generator set unloaded and loaded shall be provided.

   e. LED indicating lights for the following Faults:

      1) Fault – warning (trouble condition)

      2) Fault – alarm and shutdown

   f. Digital LCD meter with the following:

      1) kW, kW-hrs

      2) kVAR

      3) Power factor

      4) AC frequency

      5) AC amps and volts: each phase

      6) Oil temperature

7) Oil pressure
8) Low fuel pressure
9) Generator winding temperature
10) Generator bearing temperature
11) Coolant temperature
12) RPM
13) Run hours
14) System diagnostic

5. An accessible ground bus shall be furnished and securely bolted to the structural members of the panel. All equipment requiring grounding shall be connected to this bus. Bolted pressure type lugs shall be supplied at each end of the ground bus for connection of station grounding cable.

6. Bolted type terminal blocks with white marker strip shall be provided for all control and instrument wiring and shall be located for easy access and connection.

7. Pushbutton switches and indicating lights shall be heavy duty, oil tight-type.

G. Inputs and Outputs

1. Inputs

a. There shall be four dry contact inputs that can be user configured to shut down the generator or provide warning.

b. It shall be possible to define each user-configured input that will be viewable on the digital display.

c. Additional standard inputs required:

1) Input for an external ground fault detector. Digital display shall show “ground fault” upon detection of a ground fault.
2) Reset of system faults.
3) Remote two wire start.
4) Remote emergency stop.

2. Outputs

a. All NFPA 110 Level 1 outputs shall be provided.

b. Provide ten outputs available for interfacing to other equipment.

1) Outputs shall be able to be user-configured from a list of over 25 functions and faults.
2) Outputs shall be dry contacts.

c. Provide Form C dry contacts for remote summary alarms:

1) Common trouble

2) Common alarm

3. Provide the following SCADA points via an approved communications protocol:

a. Generator trouble

b. Generator running

c. Generator over crank

d. Generator low coolant temp

e. Generator high coolant temp warning

f. Generator high coolant temp shutdown

g. Generator low oil pressure warning

h. Generator oil pressure shutdown

i. Generator overspeed

j. Generator low fuel main tank

k. Generator low coolant level

l. Generator control switch not in auto position

m. Generator high battery voltage

n. Generator low battery voltage

o. Generator battery charger ac failure

p. Generator start

q. Generator remote emergency stop

r. Generator 480 V breaker mg1 tripped

s. Generator 480 V breaker mg1 closed

H. Communications

1. Generator controller shall be capable to communicate to SCADA via the following protocols:

a. Modbus Transmission Control Protocol/Internet Protocol (TCP/IP)

b. Distributed Network Protocol 3 (DNP3)

2. Provide licenses for software packages used.

I. Remote Annunciator

1. Provide remote annunciator in location as indicated on the Contract Drawings.

2. Input power: 120VAC or 24VDC, 48VDC if fed from generator batteries.

J. EPO (Emergency Stop)

1. Provide caged, lockable, emergency stop mushroom-head pushbutton switch as follows:

   a. Mount emergency stop switches on the exterior of the enclosure.

   b. Provide two emergency stop switches per engine-generator enclosure, one per each side.

   c. Mount so emergency stop switches are accessible from grade level (stair access not required).

   d. The nameplate for emergency stop switches shall read: “EMERGENCY STOP OF GENERATOR”.

2.02 AUTOMATIC TRANSFER SWITCH

A. General: An automatic transfer switch shall be furnished with the engine-generator. The transfer switch shall transfer electrical load from the utility power source to the engine-generator when the utility power source fails or is reduced more than 20 percent its rated voltage. The transfer switch shall transfer the electrical load back to the utility power source when such source is restored.

B. Type: The automatic transfer switch shall be of the 3-phase, 4-pole, 4-wire.

C. Rating: Switch rating shall be compatible with engine generator rating. The switch shall be rated for continuous duty.

D. Construction:

1. Transfer switch shall be double-throw actuated by a single electrical operator momentarily energized and connected to the transfer mechanism. The switch shall be capable of transferring successfully in either direction at 80 percent of rated voltage.

2. Normal and emergency contacts shall be positively interlocked mechanically and electrically to prevent simultaneous closing. Main contacts shall be mechanically locked in position in both the normal and emergency positions without the use of hooks, latches, magnets, or springs and shall be silver tungsten alloy and protected by arcing contacts with magnetic blowouts on each pole.

3. Transfer switch shall be equipped with manual operator that shall prevent injury to the operating personnel if the electrical operation should suddenly become energized during manual transfer. The manual operator shall provide the same contact-to-contact transfer speed as the electrical operator to prevent a flashover from switching the main contacts slowly.

4. Transfer switch shall be provided with the following accessories:

    a. Normal voltage fluctuation time delay to delay transfer and engine start, adjustable 0.5 to 6 seconds;

    b. Transfer to emergency time delay adjustable 1 to 60 seconds;

    c. Engine starting time delay, adjustable 1 to 60 seconds;

    d. Retransfer to normal time delay, adjustable 0 to 15 minutes in one minute increments;

    e. Unloaded running time delay for engine generator cooldown, adjustable 0 to 5 minutes;

    f. Momentary test switch to simulate normal power failure;

    g. Manual reset switch to retransfer to normal power;

    h. Manual reset switch to bypass time delay on retransfer to normal power supply;

    i. Engine control contacts, two normally open and two normally closed;

    j. White indicating LED light energized when automatic transfer switch has connected load to utility power source;

    k. Amber indicating LED light energized when automatic transfer switch has connected load to engine-generator source;

    l. Bypass/isolation switches for uninterrupted power to the load during switch maintenance and testing;

5. Contacts, coils, relays, timers, control wiring, and accessories shall be accessible from the front.

6. The transfer switch, complete with all timers, relays, and accessories shall be in accordance with UL 1008.

7. Assembly and Test: The switch shall be completely wired, assembled, and tested by the switch manufacturer.

2.03 COMMUNICATION CAPABILITIES

A. The transfer switch shall be capable of being connected in any of the following network configurations. Interactive software developed for ATS applications shall be available. The software shall monitor, allow alteration of values, and provide system diagnostics. All values and ATS indications shall be available through the networks.

B. Point-to-Point Connectivity: It shall be possible to connect the ATS directly to a personal computer in the following ways:

1. Local Connection - Maximum cable length 50 feet (15 meters) using RS232.

2. Remote connection shall be capable of communication via TCP/IP over ethernet through Category 6A or fiber optic via District approved media converter.

C. It shall be possible to connect a printer to the computer for hard copy generation.

D. The communication cable shall run in separate conduit to a location as specified in the Contract Drawings.

E. It shall be possible to start and run the generator set for up to 24 hours and control the transfer of the load to the generator set.

2.04 FABRICATION AND SHOP TESTS

A. Fabrication: Fabrication shall be in accordance with NEMA MG 1, NEMA ICS 6, and NFPA 70. The engine-generator set and accessories shall be painted ANSI, No. 61 gray.

B. Shop Tests:

1. Prior to shipment, each engine-generator unit shall be completely assembled and tested. Testing, tabulation of data, and calculation of results shall be in accordance with “Routine Tests,” Part 22.50 of NEMA MG 1, as applicable. Electrical power and control circuits shall be tested to ensure correctness of wiring and functional operation of equipment.

2. Defects detected during testing shall be replaced or repaired, and the component or assembly shall be retested.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install engine-generator equipment, appurtenances, and accessories in accordance with the manufacturer’s instructions and recommendations and as indicated to withstand seismic forces. Provide all components and accessories as required for a complete and operable standby and emergency power supply. Coordinate and interface installation requirements with other Sections as applicable.

B. Provide engine-generator isolation from the surrounding building to prevent transmission of vibration and the production of noise. Isolate piping, conduit, and mechanical connections from the building to the engine-generator by means of flexible connections.

C. Locate exhaust outlet at a minimum of 10 feet above ground level and at least 25 feet from outdoor ventilation intakes. Exhaust shall terminate outside the structures and discharge to a safe location.

D. Coordinate platform and stair layout, if required, with approved engine-generator enclosure Shop Drawings.

E. Install safety labels compliant to NFPA 70, Article 700.

3.02 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Field testing shall be performed in accordance with NFPA 110 and IEEE 43 requirements. Equipment and apparatus necessary for the tests shall be provided.

2. Testing equipment shall be accurate and the calibration history of each instrument used in testing shall be made available to the Engineer upon request.

3. All defects disclosed by the tests shall be rectified and the tests repeated.

4. An inspection checklist shall be prepared for each unit and auxiliary equipment. An operational test shall be performed to ensure proper operation of all systems.

5. The fuel used in the field tests shall be the same as the fuel to be used in operating the plant.

6. Provide a full fuel tank prior to any operational testing of the engine generator and return the fuel tank to the full fuel level prior to acceptance of the Contract.

B. Manufacturer's Field Services:

1. The engine-generator manufacturer shall provide appropriate field or job service at no additional cost to the District.

2. Contractor shall make all necessary arrangements with the manufacturer of the engine-generator equipment to provide on-site consultation and inspection services to assure the correct assembly and installation of the equipment, appurtenances, and accessories.

3. The manufacturer shall inspect and approve the equipment pad or foundation, the equipment enclosure, and required clearances.

4. The manufacturer shall provide minimum of eight (8) hours of maintenance and operational training for District's personnel. Training shall be broken up into smaller training segments at the discretion of the District. The Contractor shall coordinate with manufacturer and shall schedule all training dates and location with the District. All training dates scheduled by the Contractor shall be approved by the District at a minimum of two weeks prior to training. Training shall consist of both classroom and hands on equipment operation.

5. The manufacturer's representative shall make periodic visits to the site as the work proceeds as necessary for consultation and for expediting the work in the most practical manner.

END OF SECTION 26 32 13

SECTION 26 32 33

UNINTERRUPTIBLE POWER SUPPLY (UPS) FOR EMERGENCY LIGHTING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. System Description

B. Environmental Conditions

C. Electrical Requirements

D. Manufacturers

E. Electrical Characteristics

F. Components

G. Field Quality Control and Commissioning

H. Training and Manual

I. Spare Parts List

1.02 RELATED SECTIONS

A. Section 20 30 14, Seismic Performance Requirements for Equipment

B. Section 20 72 25, Factory and Field Testing

C. Section 26 33 01, DC Battery System

D. Standard Drawing ES71, Emergency Lighting UPS Single-Line Diagram

1.03 MEASUREMENT AND PAYMENT

A. Separate measurement or payment will not be made for the work required under this Section. All costs in connection with the work specified herein will be considered included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work of this Contract

1.04 REFERENCES

A. American National Standards Institute (ANSI):

1. ANSI C84.1 Electric Power Systems and Equipment – Voltage Ratings (60 Hz)

B. Federal Communications Commission (FCC):

1. FCC Rules and Regulation 47, Part 15 Radio Frequency Devices

C. International Electrotechnical Commission (IEC):

1. IEC 61000-4-2 Electromagnetic Compatibility (EMC) – Part 4-2: Testing and Measurement Techniques – Electrostatic Discharge Immunity Test

D. Institute of Electrical and Electronic Engineers (IEEE):

1. IEEE C62.41.1 Guide on the Surges Environment in Low-Voltage (1000V and Less) AC Power Circuits

E. National Fire Protection Agency (NFPA):

1. NFPA 1 Fire Code

2. NFPA 70 National Electrical Code

3. NFPA 101 Life Safety Code

F. Underwriters Laboratory, Inc. (UL):

1. UL 924 Standard for Emergency Lighting and Power Equipment

2. UL 1778 Standard for Uninterruptible Power Systems

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures; Section 01 33 23, Shop Drawings, Product Data, and Samples; and Section 01 78 23, Operation and Maintenance Data for submittal requirements and procedures.

B. Submit product information and catalog cuts of UPS equipment components and devices.

C. After the receipt of Notice to Proceed (NTP), submit within three weeks required drawings and specifications to review.

D. Include as Shop Drawings:

1. Equipment dimensions, weights, center of mass, and heat description

2. Performance curves for range of operation

3. System configurations with single-line diagram

4. Installation requirements and layouts

5. Details of construction
6. Technical data sheets
7. Wiring diagrams and bill of materials
8. Detailed layouts of power and control connections
9. Detailed installation drawings including terminal locations
10. Air flow requirements

E. Submit UPS system specifications and Shop Drawings.

F. Submit a copy of the UPS test procedure.

G. Submit a copy of the factory test report, two weeks prior to the shipment of the equipment in accordance with Section 20 72 25, Factory and Field Testing.

H. Submit table matrix showing the specification requirement and the product data showing all specifications are met.

I. Submit manufacturer qualifications.

1.06 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in UPS equipment with a minimum of five years' experience in the design, manufacturing, and testing of the UPS systems.

B. The UPS manufacturer shall be ISO 9001 certified.

1.07 WARRANTY

A. UPS: The warranty shall be for 24 months after Acceptance and shall include all costs for repair, parts, labor, travel, and living expenses for the manufacturer's service personnel. Under conditions where the UPS is determined to be unrepairable, the manufacturer shall replace it with a new UPS with comparable specifications.

B. Refer to Section 26 33 01, DC Battery system, for battery warranty.

C. The manufacturer shall dispatch the technician within 72 hours after the warranty call is requested.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

A. UPS manufacturers:

1. Online Power
2. Eaton
3. Or equal

2.02 SYSTEM DESCRIPTION

A. General

1. See Standard Drawing, ES71, Emergency Lighting UPS Single-Line Diagram for details.
2. The UPS system shall include a UPS cabinet, external maintenance bypass cabinet (MBC), battery cabinet, batteries, isolation transformers, static transfer switch, and other system components as indicated.
3. The UPS system shall be UL 924 and UL 1778 listed and follow NFPA 101 recommended guidelines.
4. The UPS system shall be provided by one manufacturer.
5. The UPS equipment shall be categorized as Critical, Seismic Design Category D. See Section 20 30 14, Seismic Performance Requirement for Equipment, for seismic testing and certification requirements.

B. Modes of Operation

1. UPS
   a. The UPS shall be online type, fully automatic, and reverse transfer system.
   b. Normal operation: The rectifier shall derive power from the input AC source and supply DC power to the inverter while simultaneously float charging the battery. The critical load shall be continuously supplied by the inverter and the output AC voltage shall be fully regulated.
   c. Loss of normal power: Upon failure of AC input power, emergency loads shall continue to be supplied by the inverter without any switching and shall obtain its power from the battery system. There shall be no interruption of power to the critical load upon failure or restoration of the commercial AC source.

d. Return of normal power: Upon restoration of AC input power, the rectifier shall provide power to the inverter and simultaneously recharge the batteries. This shall be an automatic function and cause no interruption of power to the load. The transfer to normal input power shall be initiated only after ascertaining stable return of input AC voltage after several cycles.

e. Bypass mode: When placing the UPS out of service for overload or internal failures, the static bypass switch shall automatically transfer the load without interruption to the AC input power. Retransfer of the load to normal operation mode shall be automatic after the overload or failure has been cleared and reset. Transfer to bypass shall be capable through manually performed operation.

f. Operation Without Batteries: When batteries are taken out of service, the UPS shall be disconnected from the batteries through an internal battery circuit breaker. The UPS shall continue to function and meet performance criteria specified herein, except for reserve time capability.

g. External Maintenance Bypass: The external maintenance bypass cabinet shall transfer the load without power interruption to the loads.

C. Power Rating

1. Field upgradable: 20 percent margin of UPS rating.

2. Battery system: Minimum 90 minutes at full rating of UPS output power.

2.03 ENVIRONMENTAL REQUIREMENTS

A. The UPS shall withstand any combination of the following external environment conditions without operational degradation.

1. Operating temperature: 32 degrees to 120 degrees Fahrenheit (0 degrees to 50 degrees Celsius).

2. Relative Humidity: 0 percent to 95 percent non-condensing (operating and storage).

3. Elevation: 1,000 meters above mean sea level without derating.

4. Refer to Section 26 33 01, DC Battery System, for additional external environmental conditions.

2.04 ELECTRICAL REQUIREMENTS

A. Efficiency

1. The overall system AC-to-AC efficiency shall be determined by dividing the output power by the input power.

2. The minimum acceptable efficiency values shall be 83 percent at 50 percent rated load, 84 percent at 75 percent rated load, 86 percent at 100 percent rated load.

B. Components

1. Active electronic devices shall be solid-state and not exceed manufacturer recommended tolerances.

2. Semiconductor devices shall be sealed.

3. Relays shall have dust covers.

C. Grounding

1. The UPS shall be a separately derived system. AC output neutral shall be electrically isolated from the UPS chassis, battery, and main AC input.

D. Conductors

1. Wiring, including transformers, inductors, and other conductive components shall be copper.

2. Exposed copper surfaces shall be treated with permanent protective coating electrically equivalent to tin.

3. Aluminum for wiring, foil, bus work, and as a current carrying media shall not be used.

4. Aluminum heat sinks are permissible provided no electrical current passes through the part.

E. Transformers

1. Input and output transformers shall be isolated winding type.

2. Windings shall be copper.

3. Input transformers shall have an electrostatic shield between primary and secondary windings for noise isolation and suppression.

4. Insulation type shall have a temperature rating greater than the highest winding temperature during worst case UPS operation.

5. Transformer connections shall be accessible from the front of the enclosure to facilitate periodic inspection and maintenance.

F. Materials

1. Materials and parts of the UPS shall be new and not have been in prior service except as required during factory testing.

2. Metal surfaces shall be treated with permanent corrosion inhibiting protective coating.

G. Surge, Sag, and Impulse Protection

1. The UPS shall have built-in protection against sag, surge, and impulse disturbances for main and bypass AC input sources per IEEE C62.41.1 recommended guidelines.

H. Reliability and Maintainability

1. Mean Time Between Failure (MTBF): The UPS module shall have a MTBF of 100,000 hours minimum. The requirement shall be based on representative data from installed UPS models of specified series or rating. For the purpose of determining specified reliability, the bypass AC input source shall not be used as an enhancement method.

2. Mean Time to Repair (MTTR): Shall not exceed 30 minutes when returning UPS to normal mode.

3. Power cables to power transformer and chokes shall be secured with permanent cold weld crimps.

4. Faults shall be isolated to least replaceable unit (LRU).

I. Overtemperature Protection

1. The UPS cabinet, rectifier/charger, and inverter heat sinks shall be protected by temperature sensors to allow for UPS shut down to prevent semiconductor devices from damage.

2. The temperature sensor shall signal the UPS to transfer critical loads to bypass, report the fault conditions, and send alarm indications.

3. EMI Suppression: The UPS shall meet FCC rules and regulation 47, part 15, subpart J, for class A devices.

4. Electrostatic Discharge (ESD): The UPS shall meet IEC 61000-4-2.

2.05 ELECTRICAL CHARACTERISTICS

A. Nominal voltage ratings and operating tolerances shall be in accordance to ANSI C84.1 recommended guidelines.

B. Input Rating:

1. Input Voltage: 480 VAC, 3 phase, 4 wire

2. Input Voltage Range: plus 10 percent, minus 15 percent

3. Frequency Range: 55 to 65 hertz

4. Phase Imbalance: The UPS shall not be impacted by input line phase up to plus or minus 10 percent. The output phase unbalance shall not be contributed by the UPS inverter
5. Power Factor: 0.8 lagging to 0.8 leading at full load
6. Current Limit: 125 percent full load maximum
7. Inrush Current: Soft start shall be used to limit not more than 1.5 times the full load for a duration not exceeding 100 milliseconds
8. Total Harmonic Distortion (THD): less than 5 percent

C. Output Rating:

1. Output Voltage: 480 VAC, 3 phase 4 wire
2. Frequency: 60 Hz, plus or minus 0.5 Hz, nominal
3. Output Voltage Regulation: Within plus or minus 2 percent of output voltage
4. Power Rating: As indicated
5. Power Factor: 0.8 minimum
6. Voltage Transient: shall not exceed plus or minus 5 percent for any change in load
7. Overload: 125 percent for 10 minutes and 115 percent for one hour
8. Cabinet size: As indicated
9. Battery run time: Minimum 90 minutes at full load
10. Phase Imbalance: 100 percent

2.06 COMPONENTS

A. Rectifier/Charger

1. The rectifier/charger shall be silicon controlled rectifier (SCR) type in 12-pulse configuration or insulated gate bipolar transistor (IGBT) with power factor correction (PFC) including capability of converting incoming AC power to regulate DC output for supplying the inverter and charging of the battery bank.
2. The rectifier/charger shall support a loaded inverter and recharge the batteries per UL 924 requirements.

3. The rectifier/charger shall be temperature compensate type and shall automatically boost charge the battery after battery drain.

4. Boost charging shall stop if ambient temperature exceeds 35 degrees Celsius.

5. Provide controlled charging and load exercising of batteries to prevent battery deterioration.

6. The charger unit shall be programmable and expandable up to 20 percent in power rating for additional battery modules.

7. Provide output filtering to limit AC ripple current per manufacturers' recommended guidelines.

8. The battery charger shall work in conjunction with the battery management system (BMS) to disable to the charger for instances where high levels of hydrogen or over temperature conditions are detected.

B. Inverter

1. The inverter shall be high frequency switching converter type with IGBT technology.

2. The inverter shall be capable of providing the specified quality output power while operating from any DC voltage source (rectifier or battery) within the specified range.

3. The inverter shall have input and output filtering, circuits for regulation, protection, and monitoring.

4. The inverter shall be self-protected.

5. The UPS output power shall be phased synchronized with AC input power at all times.

C. Internal Bypass (Static Transfer Switch)

1. The static transfer switch and bypass shall be provided as an integral part of the UPS.

2. The control unit shall include alarm conditions and transfer circuitry to sense status of the inverter logic signals during uninterrupted transfer of the load to bypass.

3. Uninterrupted transfer shall be inhibited if the alternate power source is not within specifications.

4. Uninterrupted transfer to static bypass shall turn the inverter off and be automatically initiated for the following conditions:

   a. Inverter under-voltage

b. Inverter over-voltage

c. Inverter overload

d. Inverter over temperature conditions

e. Total battery discharge

f. UPS fault

g. Manual initiation

5. No transfer shall take place during the following conditions:

a. Bypass out of synchronization

b. Bypass phase rotational/installation error

6. The rectifier/charger input circuit breaker shall not affect bypass operation.

7. Return to normal mode operation shall occur automatically except for inverter failure or overload.

8. Surge protection: The static transfer switch shall have surge protection on alternate source side.

D. Input and Output Bypass Protection

1. Provide thermal-magnetic molded case circuit breakers and transient suppression circuitry.

E. Maintenance Bypass Cabinet (MBC)

1. Provide external MBC to allow complete isolation of the load from the UPS.

2. The MBC shall be used to bypass the UPS as required.

3. The MBC shall include a 5 kVA auxiliary transformer, that provides 120/208 VAC up to 5 kVA. Utility and auxiliary transformer neutrals shall be routed to the neutral terminal block with an option to add or remove factory default jumper.

4. Each UPS shall have its own external MBC.

5. MBC shall have a single handle switch for ease of operation.

6. MBC shall interface with the UPS cabinet for seamless load transfer to utility power source for bypass operation and safe disconnection.

7. The MBC shall include associated input and output terminals, breakers, indicators, and auxiliary transformer for input and output of the UPS cabinet.

8. Breakers for main and auxiliary output shall be provided and labeled as indicated.

9. The MBC shall include the following:

    a. Cabinet type: NEMA 1

    b. Input Voltage: 480 VAC, 3 Phase, 4 wire

    c. Main Output Voltage: 480/277 VAC, 3 phase, 4 wire

    d. Main Output Load: Same as UPS

    e. Auxiliary Output Voltage: 120/208 VAC, 3 phase, 4 wire

    f. Auxiliary Output Load: 5 kVA

    g. Cooling: Natural convection with louver

    h. Input/Output terminals: Terminal blocks

    i. Interlock: The MBC shall be electrically interlocked to protect back feeding to the UPS output in the event of incorrect operation.

    j. Alarm: The UPS shall produce a continuous audible alarm upon transfer to bypass mode that indicates to the user that loads continue to be powered from the utility or generator supply alone. The audible alarm shall be capable of being muted by the user and shall have an indicator light that remains lit under these conditions.

    k. Indicators: Indicators for MBC shall be LED type.

    l. Dry contacts: Provide separate dry contacts, two sets of Normally Open (NO) and Normally Closed (NC), to provide status of the MBC.

F. Battery and Battery Cabinet

1. Batteries, battery cabinets, and accessories shall be in accordance with Section 26 33 01, DC Battery System.

2. The stationary storage battery system shall be sized to meet or exceed the 100 percent UPS output requirement for a minimum of 90 minutes. The individual battery shall be sealed, maintenance free, non-gassing absorbed electrolyte type with automatic/self-sealing safety vents, heavy duty integral copper terminals, heavy duty lead plated copper connectors, and stainless-steel bolts with lock washers.

3. The batteries shall be housed in a separate cabinet and designed to match the UPS enclosure.

4. Battery short circuit protection shall be provided by a molded case circuit breaker located in the battery cabinet.

5. The circuit breaker in each battery cabinet shall have auxiliary switch for alarm and monitoring for open battery circuit breaker conditions.

6. Battery Management System (BMS):

    a. Refer to Standard Drawing ES89, Typical Battery Management System, for additional requirements.

    b. Enclosure for BMS equipment shall be NEMA Type 1.

    c. The BMS power supply shall be 120 VAC in, 24 VDC out, 5A, din-rail mounted, as indicated. Provide DC-DC converter, 5A, din-rail mounted, for BMS components requiring differing voltage levels as required.

    d. The BMS shall be equipped with an IP addressable port, Ethernet (TCP/IP), and be compatible with Modbus TCP/IP network protocols for remote monitoring and management of the system.

    e. The BMS shall be capable of monitoring and managing individual battery charging voltage.

    f. Provide battery time or percent remaining when operating in normal or battery mode. Battery time available shall be displayed in real time under changing load conditions. Information for battery time availability shall be within plus or minus 3 percent.

    g. The BMS shall automatically analyze the UPS battery during user defined periodic test. During the test, the rectifier/charger shall not de-energize and shall share the load with the battery. For remaining battery time information, the battery shall test under the same load for each user defined periodic test. If the battery is weak or defective, the battery management system shall detect and annunciate the battery failure condition without transferring the critical load to bypass mode.

    h. The periodic test performed by the BMS shall not remove more than 10 percent of the available run time from the battery. The monthly periodic test shall not reduce overall battery life.

    i. If utility outage occurs during a test, the test shall be discontinued and subsequently conducted at the next programmed interval. The occurrence of the test shall be user programmable for day, date, and time.

    j. The BMS shall record and display the pass and fail status, battery voltage, and indicator value of previous 30 periodic tests.

    k. The BMS shall annunciate a battery time remaining warning when the UPS is on battery power.

    l. The BMS shall provide an imminent shut down alarm to signal a low battery condition.

    m. The BMS shall be capable of managing valve regulated lead-acid (VRLA) batteries.

    n. The BMS shall include a hydrogen detection module, hydrogen gas sensor, siren, and strobe light. Hydrogen detection threshold for lower explosive level (LEL) shall be set per NFPA 1 requirements.

G. Supplemental Battery Charger

1. Refer to Section 26 33 01, DC Battery System, for requirements.

H. Control Design and Operating Characteristics

1. Ethernet (TCP/IP) communication cable shall be CAT 6A type, RJ45 connector, shielded, with drain wire. Refer to Section 27 13 01, Communication Cables and Related Equipment, for details and grounding requirements.

2. Provide a control and monitoring panel including metering, monitoring, and control function with an Emergency Power Off (EPO) pushbutton located on panel surface.

3. Start up and transfer shall be automatic functions.

4. The IP addressable, Ethernet (TCP/IP) control and parameters shall be made available locally and remotely. The remote Ethernet (TCP/IP) interface shall be reserved for remote operation, monitoring, and be compatible with Modbus TCP/IP network protocol.

5. Remote I/O (Input/output) signals shall be interfaced with Ethernet (TCP/IP) and shall include remote monitored signals for the following:

    a. Input voltage line-to-line

    b. Input voltage line-to-neutral

    c. Input current

    d. Output voltage line-to-line

    e. Output voltage line-to-neutral

    f. Output current

    g. Rectifier voltage

    h. Rectifier current

    i. UPS fault

    j. Battery voltage

    k. Input AC failure

    l. UPS in static mode

    m. UPS in bypass mode

    n. Testing Status

6. Failure of battery cells within a string caused by over voltage conditions shall automatically send trouble alarm notifications and be capable of being remotely monitored.

I. Metering

1. Front panel display: provide touch screen LCD and selector switches with reading and setting parameters.

2. Parameters: parameters shall be individually metered with a digital read-out that produces an accuracy of two percent or greater for the following:

   a. Input voltage (line-to-line)

   b. Input voltage (line-to-neutral)

   c. Input current (per phase)

   d. Output voltage (line-to-line)

   e. Output voltage (line to neutral)

   f. Output current (per phase)

   g. Bypass source voltage (per phase)

   h. Bypass source current (per phase)

   i. Rectifier/charger: DC voltage, DC current

   j. Battery voltage

   k. Battery system (time until discharge)

   l. Input power: kW, kVA, kVAR

   m. Output power: kW, kVA, kVAR

   n. Frequency: inverter, AC power source, load

   o. UPS fault

   p. Battery voltage

   q. Input AC failure

   r. UPS in static mode

   s. Testing status

J. Indicators

1. Monitoring components: The following components shall provide monitor and control capability:

   a. Micro-controller driven circuitry

   b. Monitor panel with status indicators

   c. Alarm and metering display

   d. Various communication ports

2. Monitor Panel Indicator: The UPS module shall include a monitoring panel with the following functions and indicators:

    a. NORMAL: For operation in normal mode.

    b. BATTERY: For operation in battery mode and main input utility power failure.

    c. BYPASS: For operation in bypass mode and support of critical loads.

    d. NOTICE: Indicators shall be lit and accompanied by an audible alarm for items requiring attention.

    e. STANDBY: For operation in standby mode.

    f. ALARMS: Indicators shall flash for abnormal conditions or for notifications requiring immediate attention. The alarm contacts shall remain latched until reset.

    g. ALARM SILENCE: Provide an alarm reset button for display panel. If the alarm reset button is held for 1 second, the current audible alarm shall be disabled. Alarms that occur after reset shall continue to provide an audible alarm signal.

    h. AUTOMATIC MESSAGING SYSTEM: An automatic dial signal shall be generated for telephone and messaging communications in the event of failure to the UPS, including input AC power failure.

    i. An audible alarm shall be provided for individual alarm and notice conditions.

    j. Indicator lights shall be LED type.

K. Enclosures

1. Rectifier/charger, inverter, filtering, and surge protection shall be installed in NEMA 1 cabinets.

2. Enclosures shall be designed for industrial applications and rated suitably for the surrounding environment.

3. Enclosures shall match in proportion and style.

4. Ventilation: The UPS shall include forced air cooling. Air inlets shall be placed on lower and top section of the enclosure. Air filters for the UPS shall be commonly available sizes and be easily removable from the unit.

5. No back or side clearance shall be required for any enclosure. The back and side enclosure covers shall be capable of being located directly adjacent to a wall.

6. Cable entry: Provide top cable entry with dedicated wire way within the UPS for routing user input and output wiring. Wiring compartments shall comply with NFPA 70 sizing requirements for cable turning radius.

7. Serviceable items shall be modular and be capable of being replaced from front side of UPS.

L. Anchors

1. See Section 20 30 14, Seismic Performance Requirements for Equipment, for anchoring requirements.

2.07 FACTORY TESTING

A. The manufacturer shall fully test the system to ensure compliance with the specifications prior to shipment.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install UPS system equipment as indicated and as recommended by the manufacturer. UPS equipment shall be properly anchored and restrained for seismic loading under the requirements found in Section 20 30 14, Seismic Performance Requirements for Equipment.

3.02 FIELD QUALITY CONTROL AND COMMISSIONING

A. Testing of UPS equipment shall be conducted at the Jobsite with the UPS system fully assembled.

B. Testing shall be performed by the field service personnel during the UPS startup and shall include the following:

1. Visual inspection:

   a. Visually inspect equipment for damage and foreign materials.

   b. Inspect the type of ventilation, cleanliness of room, use of proper signs, and safety related factors.

2. Mechanical inspection:

   a. Verify all the power connections, control wiring, and bracing are torqued per manufacturer’s requirements.

   b. Check all the control wiring terminations and plugs for proper seating.

3. Electrical pre-check:

   a. Check DC bus for the possible short circuit.

   b. Check input and the bypass for the correct voltage and phase rotation.

   c. Check all test functions.

4. Initial startup:

   a. Verify alarm conditions

b. Energize UPS module and verify proper DC, AC phase, and walk-up.

c. Check DC link voltage, AC output voltages, and output waveform.

d. Check final DC link voltage, and inverter AC voltage output.

e. Check for proper synchronization.

f. Check voltage difference between inverter output and bypass source.

C. The UPS power equipment manufacturer representative shall be an integral part of the commissioning team. The UPS power equipment manufacturer representative shall attend regularly scheduled commissioning meetings to assist in startup scheduling and resolve system installation conflicts prior to actual startup.

1. Pre-Startup Test: All manufacturer recommended pre-startup tests shall be performed.

2. Primary power testing:

   a. Primary power shall only be applied after successful completion of all pre-startup tests.

   b. Primary power shall be applied for 72 hours minimum with dummy load in operation and prior to the initiation of additional required tests. During the test, all functions of the UPS shall be monitored continuously.

   c. Conduct a one-time load test of the system with the load bank. Rundown time, battery backup, and recharge time of batteries shall be monitored and verified against manufacturer stated requirements or Specifications as indicated.

D. Provide equipment necessary for load testing, including a load bank equivalent to the full capacity of the UPS, and additional ventilation as required.

E. Final Acceptance Test:

1. The UPS shall be in service for a minimum of 30 Days prior to final inspection. Provide notification to the Engineer in writing within 5 working days prior to date of final acceptance testing. The UPS shall be considered ready for testing after preliminary tests are performed and defects and deficiencies have been corrected to the satisfaction of the equipment manufacturer’s technical representative and District.

2. Acceptance testing shall be performed in the presence of manufacturer representatives, construction manager, and District.

3. Furnish instruments, labor, and materials required for the tests. Any identified deficiencies shall be corrected and retested.

4. Tests shall be repeated as directed by the District during final acceptance testing period.

F. Additional Test:

1. If deficiencies or defects occur during required testing under normal operating conditions, further testing of the UPS shall be suspended until proper adjustments, repairs, corrections, and revisions have been made to assure proper performance of the system.

2. All tests required shall be repeated prior to final acceptance unless otherwise specified.

G. Maintenance Instructions: Submit the initial notification of final acceptance testing and two hardcopy sets of the following: record drawings, maintenance manuals, and wiring and interconnection diagrams. Provide one additional electronic copy with items stated herein to the Engineer.

H. Anchor Testing: See Section 20 30 14, Seismic Performance Requirements for Equipment, for testing requirements.

3.03 TRAINING

A. Refer to Section 01 79 00, Demonstration and Training for requirements.

3.04 SPARE PARTS LIST

A. UPS manufacturer shall provide a recommended spare parts list.

END OF SECTION 26 32 33

SECTION 26 33 01

DC BATTERY SYSTEM

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Batteries.

B. Battery Rectifier/Chargers.

C. Disconnect switch and circuit breaker.

D. DC Distribution panel.

1.02 RELATED SECTIONS

A. Section 20 30 14, Seismic Performance Requirements for Equipment

B. Section 20 70 26, Common Materials and Methods for Electrical Systems

C. Section 22 40 00, Plumbing Fixtures

D. Section 26 05 24, Low Voltage Wires and Cables

E. Section 26 05 26, Grounding and Bonding for Electrical Systems

F. Section 26 05 70, Electrical Cabinets and Enclosures

G. Section 26 24 24, Circuit Breakers and Panelboards

1.03 MEASUREMENT AND PAYMENT

A. Separate measurement and payment will not be made for the Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the Bid Schedule of the Bid Form, or incidental to the Work of the Contract.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM B187/B187M Standard Specifications for Copper, Bus Bar, Rod, and Shapes and General Purpose Rod, Bart, and Shapes

B. California Code of Regulations (CCR):

1. Title 24, Part 2 California Building Code (CBC)

2. Title 24, Part 3 California Electrical Code (CEC)

3. Title 24, Part 9 California Fire Code (CFC)

C. Code of Federal Regulations (CFR):

1. Title 40 - Protection of Environment

   a. Part 261.3 Identification and Listing of Hazardous Waste

   b. Part 273.1 Standards for Universal Waste Management

2. Title 49 - Transportation

   a. Part 105 Hazardous Materials Program Definitions and General Procedures

D. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE 450 IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications

2. IEEE 484 IEEE Recommended Practice for Installation Design and Implementation of Vented Lead-Acid Batteries for Stationary Applications

3. IEEE 485 IEEE Recommended Practice for Sizing Lead Acid Batteries for Stationary Applications

4. IEEE 1106 IEEE Recommended Practice for Installation, Maintenance, Testing, and Replacement of Vented Nickel-Cadmium Batteries for Stationary Applications

5. IEEE 1115 IEEE Recommended Practice for Sizing Nickel-Cadmium Batteries for Stationary Applications

6. IEEE 1184 IEEE Guide for Batteries for Uninterruptible Power Systems

7. IEEE 1187 IEEE Recommended Practice for Installation Design and Installation of Valve-Regulated Lead-Acid Batteries for Stationary Applications

8. IEEE 1188 IEEE Recommended Practice for Maintenance, Testing, and Replacement of Value-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications

9. IEEE 1189 IEEE Guide for Selection of Value-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications

10. IEEE 1375 IEEE Guide for Protection of Stationary Battery Systems

11. IEEE 1491 IEEE Guide for Selection and Use of Battery Monitoring Equipment in Stationary Applications

12. IEEE 1578	IEEE Recommended Practice for Stationary Battery Electrolyte Spill Containment and Management
13. IEEE 1635	IEEE Guide for the Ventilation and Thermal Management of Batteries for Stationary Applications.

E. National Electric Manufacturing Agency (NEMA):

1. NEMA 250	Enclosure for Electrical Equipment (1000 Volts Maximum)
2. NEMA PB 1	Panelboards
3. NEMA PB 1.1	General Instructions for Proper Handling, Installations, Operation and Maintenance of Panelboards Rated 600 Volts or less
4. NEMA PE 5	Utility Type Battery Chargers

F. National Fire Protection Association (NFPA):

1. NFPA 70	National Electrical Code (NEC)
2. NFPA 1	Fire Code

G. Underwriters Laboratories (UL):

1. UL 67	Standards for Safety Panelboards
2. UL 1642	Standard for Lithium Batteries
3. UL 1973	Standard for Batteries for Use in Light Electric Rail (LER) Applications and Stationary Applications
4. UL 1989	Standard for Standby Batteries
5. UL 489	Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures

H. American Society of Civil Engineers (ASCE):

1. ASCE 7	Minimum Design Loads and Associated Criteria for Buildings and Other Structures

I. International Code Council Evaluation Service (ICC-ES):

1. AC 156	Acceptance for Seismic Certification by Shake-table Testing of Nonstructural Components

1.05 SUBMITTALS

A. General: Refer to Specification Section 01 33 00, Submittal Procedures, Specification Section 01 33 23, Shop Drawings, Product Data, and Samples, and Specification Section 01 78 23, Operation and Maintenance Data for submittal requirements and procedures.

B. Product data and catalog cuts for battery systems.

C. Manufacturer's arrangement, wiring and detail drawing.

D. Power consumption calculations. Estimated average power and peak power demand shall be provided.

E. Battery and battery charger sizing calculations.

F. Factory test data.

G. Available short circuit current, maximum continuous current and maximum voltage ratings of the battery system.

H. The voltage, current and fault current interrupting ratings of the protective devices rated for use in a DC circuit.

I. Certificates:

1. Factory trained manufacturer's representative(s) shall certify in writing that the equipment has been installed, adjusted and tested in accordance with the manufacturer's recommendations. The contractor shall provide three (3) copies of manufacturer's representative's certification.

J. Supplier qualifications.

K. Test procedures.

L. Structural calculations and seismic qualification certification per Section 20 30 14, Seismic Performance Requirements for Equipment.

M. Special Inspection Report: Submit special inspections report performed by independent testing agency for equipment seismic qualification inspection and support anchorage installations specified in Section 20 30 14, Seismic Performance Requirements for Equipment.

1.06 MAINTENANCE MATERIALS

A. Furnish tools needed for removal and replacement of batteries or cells.

1.07 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with the following requirements:

1. CBC, CEC, and CFC.

2. CFR: Title 40, Parts 261.3 and 273.1.

3. CFR: Title 49, Part 105.

4. Applicable local, state, federal codes and standards.

B. Battery and charger components, devices and accessories shall be listed and labeled as defined in NFPA 70. The system and component shall conform to IEEE 485, IEEE 1184, NEMA 250, UL 489, NEMA PB1, and UL 67. Batteries shall be new and manufactured no more than six months prior to installation.

C. Supplier Qualifications: The manufacturer of the batteries and battery charger shall have a minimum of five years of experience manufacturing equipment furnished under the Work. Battery and battery chargers shall be proven standard products, or equivalent to the standard products of manufacturers engaged in the production of such equipment for a minimum of five years.

1.08 BATTERY ROOM EQUIPMENT

A. The battery room shall have HVAC system that shall maintain the temperature of 77 plus or minus 5-degree Fahrenheit.

B. The battery room shall have hydrogen sensor that communicates with UPS charger and sends alarm back to the Operation Control Center (OCC). When the hydrogen concentration reaches 1 percent, it shall send alarm signal to the OCC. When the hydrogen concentration reaches 2 percent, it shall disable the UPS charger and send alarm signal to Maintenance and Engineering.

1.09 DELIVERY, STORAGE, AND HANDLING

A. Batteries shall be delivered in a secured moisture proof package and per manufacture’s shipping requirements.

B. Equipment shall be handled and stored in conformance with manufacturer’s instructions. A copy of these instructions shall be included with the equipment at the time of shipment.

C. Batteries shall be placed on charger for storage times exceeding one month.

1.10 PROJECT OR SITE CONDITIONS

A. The battery charger shall be suitable for the operation under the following conditions:

Ambient Temperature Ranges:

1.	Minimum daily temperature	19.4 degrees Fahrenheit
2.	Maximum daily temperature	104 degrees Fahrenheit
3.	Maximum daily average temperature	86 degrees Fahrenheit

1.11 WARRANTY

A. The warranty for the batteries and battery charger shall be provided and signed by the manufacturer and installer to correct any deficiencies and replace components that fail in materials or workmanship.

B. Batteries shall have a warranty of ten years starting from the date it is placed in service.

PART 2 – PRODUCTS

2.01 SYSTEM REQUIREMENTS

A. General:

1. The battery systems shall include batteries, battery charger, battery racks/cabinets, disconnect switch, DC distribution panel, and related accessories to provide a fully functioning system.

2. Refer to Section 26 34 37, Uninterruptable Power Supply (UPS) for Battery Rectifier/Charger specifications.

3. The battery system shall be installed in a ventilated room in compliance with NEC and NFC standards. An exhaust ventilation system composed of a fan, ducting, and a hood, shall be provided to remove potentially hazardous emitted gases from the batteries.

4. Provide a battery containment system with neutralizing pads for the batteries in compliance with NEC and NFC standards.

5. Provide air flow sensors, associated electronics, and monitoring circuits to provide local and remote alarming to the Operation Control Center (OCC) through Supervisory Control And Data Acquisition (SCADA). As a back-up to the monitoring circuits provide a hydrogen sensor to disable the charging system to the battery system.

6. The battery system shall be sized to provide an additional 20 percent capacity over the calculated equipment power.

7. The battery system shall be installed for ease of maintainability.

8. Provide interface cables, accessories, and battery racks/cabinets.

9. Battery racks/cabinets equipped with slide trays shall automatically disable the batteries on the slide tray from the system when accessed for service.

10. Batteries shall be designed to comply with UL standards. Battery selection, sizing, installation, maintenance, testing, and replacement shall be performed per relevant IEEE guidelines and recommended practices. If an IEEE guideline or recommended practice does not exist for a particular battery type, submit proposed specifications for the battery type.

B. Manufacturers:

Examples of manufacturers of battery components specified for the Work include the following:

1. Lead Acid Batteries:

   a. Eastpenn

   b. C and D Power System

   c. Exide Technologies

   d. EnerSys

   e. Or equal

2. Nickel-Cadmium (NiCad) Batteries:

   a. Alcad

   b. SBS

   c. Edison

   d. Or equal

3. Lithium Ferrophosphate Batteries (LFP, LiFePO4)

   a. Ampetus

   b. Valence

   c. BYD

   d. Or equal

C. Lead Acid Batteries

1. The batteries or cells shall be heavy-duty, sealed, maintenance-free, and contain solid copper, lead-plated posts in individual cells with the following:

   a. The batteries or cells shall be sealed valve regulated lead acid type (VRLA), gel, or AGM (absorbent glass mat), with a minimum of ten (10) years of life under normal usage.

   b. Individual batteries or cells shall be molded, durable, and impact resistant.

   c. Battery or cell posts shall be bolted with lead plated copper bars using stainless steel hex-head nuts.

   d. The batteries or cells shall contain a sufficient number of cells to provide nominal floating voltage as indicated.

   e. The battery capacity shall be sized in accordance with IEEE 485. Establish the required capacity in rated ampere-hours to 1.75 V per cell at 77 degrees Fahrenheit as indicated.

   f. No venting of any gas under normal operation.

   g. Individual batteries or cells shall be equipped with self-resealing flame arresting safety vents.

   h. Batteries shall be fully charged prior to arrival to the Jobsite.

   i. Batteries shall be stored in a temperature controlled area of 65 degrees Fahrenheit plus or minus 5 degrees Fahrenheit, and on trickle charged when not in service.

   j. Receipt of proper disposal of batteries and recycle certificate shall be submitted to the Engineer.

D. Nickel-Cadmium (NiCad) Batteries

1. The battery modules shall be of heavy-duty design with solid copper or solid brass terminals in individual modules. The batteries shall have the following:

   a. The battery cells shall be nickel-cadmium type with a minimum of twenty (20) years of life under normal usage.

   b. The battery shall consist of individual cells in molded, durable and impact resistant modules.

   c. The battery cell posts shall be connected with bolted copper bars or bolted copper battery cables using stainless steel hex-head nuts. Other locking connectors may be used with Engineer approval.

   d. The batteries shall consist of sufficient number of cells to provide floating voltage as indicated.

   e. The battery capacity shall be sized in accordance with IEEE 1115.

   f. Batteries shall be fully charged upon arrival at the Jobsite.

g. Batteries shall be stored in a temperature controlled area of 65 plus or minus 5 degrees Fahrenheit, and on trickle charge when not in service.

h. Receipt of proper disposal of batteries and recycle certificate shall be submitted to the Engineer.

E. Lithium Iron Phosphate (LFP, also known as LiFeP04)

1. The battery modules shall be heavy-duty, maintenance free and contain solid copper or solid brass terminals in individual modules with the following:

a. The battery cells shall be LFP type with a minimum of fifteen (15) years of life under normal usage.

b. The battery consists of individual cells in molded, flame-retardant, durable and impact resistant modules. Battery modules shall have integrated, micro-processor based cell balancing and protection against thermal runaway.

c. The battery cell posts shall be connected with bolted copper bars or bolted copper battery cables using stainless steel hex-head nuts. Other locking connectors may be used with Engineer approval.

d. The batteries shall contain a sufficient number of cells to provide nominal floating voltage as indicated.

e. Establish the required capacity in ampere-hours (as specified for that location) considering the corresponding rated capacity of the battery modules at 105 degrees Fahrenheit as indicated. Battery system capacity calculations shall be completed in accordance with the battery manufacturer’s recommendations.

f. Batteries shall be fully charged prior to arrival at the Jobsite.

g. Batteries shall be stored in a temperature controlled area of 65 plus or minus 5 degrees Fahrenheit, and held at 40 percent state of charge when not in service.

h. Receipt of proper disposal of batteries and recycle certificate shall be submitted to the Engineer.

F. Ratings:

1. The battery voltage rating shall be as indicated. Batteries or cells shall have ampere-hour capacity to provide rated power to all connected equipment and devices for as specified hours as indicated.

2. The battery shall be able to retain full capacity during long term float service without maintenance.

3. The battery shall be sized to provide full operation in accordance with IEEE 485.

4. Battery system dimensions as indicated.

G. Battery/Cell Containment:

1. The individual battery or cell housing shall be heat-resistant and shall not deteriorate or become cloudy upon exposure to the electrolyte.

2. Covers shall be cemented in place to provide a permanent leak-proof seal.

3. Cell terminal posts shall be clearly and permanently identified.

H. Name Plate:

1. Each battery or cell shall be legibly and permanently marked with the following:

   a. Manufacturer's name

   b. Battery and cell type

   c. One-minute, one-hour, and eight-hour ampere ratings

   d. Month and year of manufacture

   e. Ampere-hour capacity for as specified hours

I. Accessories:

1. Each battery slot shall have a labeled identification number to mark its position within the string.

2. Provide one (1) rack mounted thermometer for battery ambient temperature.

3. Each battery system shall have an identification label for each corresponding location and date of installation.

J. Battery Charger:

1. The battery chargers shall be fully regulated with power semiconductor devices, convection-cooled, and constant-voltage type complying with NEMA PE 5. The charger shall be rated in its operation for the voltage level and number of phases that is designed consistent with its voltage and current rating.

2. The enclosure shall be NEMA 250, Type 1 and be provided with a hinged front panel complete with a lockable handle and two point latches, minimum.

3. Rating:

   a. Capacity: In accordance with its associated battery size and continuous DC load

   b. Recharging: Capable of recharging the fully discharged battery capacity as soon as safely possible without compromising the battery life. The rate of charging current to the battery module shall be such that it will not overheat the batteries and is consistent with battery manufacture's specifications for its safe operation.

c. Output current: In accordance with its battery size and continuous DC load.

d. Regulation: Plus 1 percent of output DC voltage over its complete load range with plus 10 percent variation of input AC voltage.

e. Current limiting: Trickle chargers: adjustable from 90 to 115 percent, factory set at 110 percent of output normal current rating.

f. Voltage Regulating: Float chargers: adjustable from 90 to 115 percent factory set at 110 percent of output normal voltage rating.

4. The battery chargers shall be equipped with the following features:

a. One DC voltmeter, voltage rating as indicated

b. One DC ammeter, range as indicated

c. One AC input pilot light, labeled AC POWER ON

d. Float-equalize switch shall have a mechanism to prevent from rotating

e. Adjustable float and equalization voltage adjusting potentiometer or digital equivalent

f. Two ground detection alarm relays, positive and negative, for local and remote supervisory annunciation

g. Output AC ripple shall be limited to 0.5 percent at max charging current at battery charger

h. AC input molded case circuit breaker, UL 489

i. DC output molded case circuit breaker, UL 489

j. Output DC failure alarm relay, for local and remote supervisory annunciation SCADA

k. AC failure alarm relay, for local and remote supervisory annunciation

l. Surge and transient protection

m. DC high-low voltage alarm relay

n. DC output thermal-magnetic circuit breaker

o. Battery monitoring system shall provide early warning of battery failure and equalization of charge current to each battery cell

p. Space heaters, as indicated

K. Supplemental Battery Charger:

1. Supplemental charger shall be provided.

2. Supplemental charger shall be provided to charge the battery when main charger is not available. When a battery string is integrated with a UPS system then the supplemental charger shall be disconnected.

3. Supplemental battery charger shall be provided for each battery string.

4. The supplemental battery charger shall stop the charging automatically after the batteries are fully charged.

5. The supplemental charger shall be 120 V AC or 208 V AC, 60 Hz single phase input. The output shall be consistent with the battery string voltage.

L. Emergency Eye Wash Station:

1. Provide an eye wash station in accordance with Specification Section 22 40 00, Plumbing Fixtures.

M. Disconnect Switch and Circuit Breaker:

1. Provide a two-pole hand-operated disconnect switch between the battery and the battery charger.

   a. Rating of the switch shall be coordinated with the DC output circuit breaker of battery charger.

   b. The disconnect switch shall be a surface mounted NEMA Type 12 enclosure.

   c. The disconnect switch shall be provided with two normally open (NO) and two normally closed (NC) contacts for monitoring and interlocks.

2. Circuit breakers shall be UL 489 molded case, quick-break, bolt on type, thermal-magnetic type overload trip, suitable for AC/DC operations, and rated for the voltage and current requirements as indicated.

N. DC Distribution Panelboards:

1. General:

   a. The DC distribution panel boards shall comply with the requirements of UL 67, NEMA 250, UL 489, and NEMA PB 1 as indicated.

   b. Each distribution panel board shall contain a main power circuit breaker and branch circuit breakers with spacer blanks and bus provision for future branch circuit breaker installation, as indicated.

   c. The panel board shall be in NEMA Type 1, door-in-door enclosure made of galvanized steel, for surface mounting with multiple knockouts and wiring gutters.

d. Each distribution panel board shall be provided with a panel door with full length piano hinges and a flush spring latch.

e. The panel door shall include dead front circuit breaker handles and circuit breaker card directory.

f. Interior components shall be mounted on a back plate of reinforce steel for rigid support and accurate alignment.

g. A moisture resistance circuit identification chart shall be furnished and attached to the inside face of the cover.

h. Fuses: DC loads that are used from the battery system shall have a fuse to protect the battery system and load.

2. Electrical Requirements:

a. The interrupt rating capacity of the panelboard shall be sized in accordance to the calculated device duty of the system, or 10,000 amperes, whichever is greater. Panelboards shall be equipped with two pole molded case circuit breakers and positive and negative bus bars.

b. Bus bars shall be ASTM B187/B187M, 98 percent conductive copper, with silver plated contact surface.

O. Finishes:

1. Battery racks/cabinets shall be treated with a minimum of two coats of gray acid-resistant epoxy paint.

2. The distribution panel shall be cleaned, primed and finish painted in accordance with the manufacturer's standard specifications, suitable for indoor service. The color of exterior finish paint shall be ANSI 61 gray polyester powder finish unless otherwise specified.

P. Source Quality Control:

1. General

a. Notification of Test: The District shall be notified not less than 30 Days in advance of scheduled test dates. Test procedure shall be approved by the District prior to the dates of schedule tests.

b. Test Program Plan: Submit a plan identifying the approach to be used for accomplishing the required shop tests. The projected schedule for the test and test execution, and submittal of the test results shall be included.

c. The test procedures shall include as a minimum:

1) Objective and scope

2) Test set up

3) Test equipment to be used

4) Personnel required for the test

5) Estimated duration of the test

6) Pass/fail criteria

7) Samples of data sheets to be used

8) Test procedures shall be submitted not less than 30 Days prior to test

2. Test Results: Test results will be reviewed and accepted by the District representative as a submittal. Test results that do not comply with the requirements as indicated shall be retested, documented, and submitted to the District.

3. Test Reports: Test reports shall document the results, be certified by the manufacturer, and shall include the following:

   a. Equipment tested including model and serial numbers

   b. Title of the test

   c. Objective of the test and pass/fail criteria

   d. Summary and conclusion

   e. Location and date of test

   f. Test methods and equipment used for the test

   g. Results including calculations and other supporting data

   h. Abbreviations and references

   i. Signature of the test supervisor and witnesses.

4. Test Witnessing: The District reserves the right to witness tests including factory tests conducted elsewhere by the Contactor, Suppliers, or by an independent agency. If the District determines not to witness a test, the test report shall be submitted to District for review, and signed by witnessing parties.

5. Test Equipment: Provide annually certified calibrated test equipment, instruments, tools, and other required items necessary to perform the test as indicated.

Q. Replacement Materials:

1. Replace or repair equipment, parts, and materials that are rejected, damaged, lost, or consumed during performance of shop tests. Replacement materials shall be new and warranted.

R. Factory Tests:

1. The factory test shall include design and production tests performed by the Contractor, Supplier, or a testing agency prior to the shipment of the equipment. Unless otherwise indicated, the District may waive the requirements for design tests upon review of test procedures, test results or certified documentation of like equipment. Tests results on like equipment or materials shall be submitted for design tests that are to be waived.

2. The factory test shall include the following tests for the DC control power supply:

   a. Temperature rise test

   b. Power loading at 100 percent capacity for 24 hours at 89.6 degrees Fahrenheit and 90 percent humidity.

2.02 EQUIPMENT SUPPORTS

A. Provide equipment supports for battery systems in accordance with Section 20 30 14, Seismic Performance Requirements for Equipment.

PART 3 – EXECUTION

3.01 INSTALLATION

A. The Contractor shall install the battery and battery charger including the associated devices in the train control battery rooms or other BART facilities with the manufacturer's recommendations and as indicated.

B. The installation of DC distribution panelboards shall comply with the requirements of NEMA PB 1.1

C. Battery and Battery Charger:

1. The battery and rack/cabinet assembly shall be arranged to provide easy access to each battery cell or module for maintenance and replacement.

2. The cables or the bus bars between battery cells or modules shall be securely connected.

3. The battery charger shall be installed as indicated.

3.02 FIELD QUALITY CONTROL

A. A power distribution test shall verify that energy at all levels is available and is properly distributed to the equipment requiring power in the train control rooms and other BART facilities. The test shall include the following verifications:

1. No grounds, short circuits, open circuits, or misplaced wiring exist.

2. Standby, reserve, and battery power circuitry are complete.
3. Output AC power supplies:
    a. Provide the voltage level as indicated
    b. Provide phasing as required
    c. Record voltages
4. Output DC power supplies:
    a. Provide the correct voltage level as indicated
    b. Provide proper polarity
    c. Record voltage and loads
5. Adjust transformer or voltage regulators as indicated.
6. Test ground fault detectors for operability.
7. Perform a visual inspection of mechanical and electrical system components in accordance with ANSI/NETA-ATS testing standards.

B. Acceptance Tests

1. The Contractor shall perform a minimum one hour load testing to verify the battery discharge rate is consistent with the specified battery run time.

3.03 CLEANING

A. Upon completion of installation, inspect the batteries, battery charger, and ancillary equipment. Remove paint splatter and other spots, excess materials, vacuum dirt and debris, and repair any damage or scratches to exposed surfaces to match original finish.

B. Receipt of proper disposal of hazardous waste material and waste recycle, such as recycle evidence, shall be submitted to the Engineer. Refer to Section 01 74 21, Waste Management for waste management requirements.

3.04 DEMONSTRATION

A. A factory authorized service representative shall demonstrate the operation of equipment for the District's maintenance personnel to adjust, operate, and maintain DC power system controls, protective devices, instrumentation, and accessories.

END OF SECTION 26 33 01

SECTION 26 34 37

UNINTERRUPTIBLE POWER SUPPLY (UPS)

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. System requirements.

B. Rectifier/charger.

C. Inverter.

D. Static transfer switch.

E. External maintenance bypass cabinet (MBC).

F. Batteries.

G. Controls.

H. Metering.

I. Indicators.

J. Remote monitoring.

1.02 RELATED SECTIONS

A. Section 26 33 01, DC Batteries

B. Train Control UPS Single-Line Diagram, Typical, Standard Drawing ES70

C. Emergency Lighting UPS Single-Line Diagram, Typical, Standard Drawing ES71

1.03 MEASUREMENT AND PAYMENT

A. Separate measurement and payment will not be made for the Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the Bid Schedule of the Bid Form, or incidental to the Work of the Contract.

1.04 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures; Section 01 33 23, Shop Drawings, Product Data, and Samples; and Section 01 78 23, Operation and Maintenance Data for submittal requirements and procedures.

B. Submit product information and catalog cuts of UPS equipment components and devices.

C. After the receipt of Notice To Proceed, submit within three weeks required drawings and specifications for review.

D. Include as Shop Drawings:

1. Equipment dimensions, weights, and heat description
2. Performance curves for range of operation
3. System configurations with single-line diagram
4. Installation requirements and layouts
5. Details of construction
6. Technical data sheets
7. Wiring diagrams
8. Detailed layouts of power and control connections
9. Detailed installation drawings including terminal locations
10. Air flow requirements

E. Submit UPS system specifications to the Engineer.

F. Review of Shop Drawings by the Engineer for general conformance only and shall not relieve the Contractor of responsibility for supplying equipment which complies with the specifications and functional requirements and good engineering practice.

G. Submit a copy of the factory test report to the District, two (2) weeks prior to the shipment of the equipment in accordance with Section 20 72 25, Factory and Field Testing.

1.05 REFERENCES

A. American National Standards Institute (ANSI):

1. ANSI C84.1 Electric Power Systems and Equipment – Voltage Ratings (60 Hertz)

B. International Electrotechnical Commission (IEC):

1. IEC 60068-1 Environmental Testing Part 1: General and Guidance

C. Institute of Electrical and Electronic Engineers (IEEE):

1. IEEE C62.41 IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits

2. IEEE 446 IEEE Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications

3. IEEE 1184 IEEE Guide for Batteries for Uninterruptible Power Supply Systems

D. Federal Communications Commission (FCC):

1. FCC Rules and Regulation 47, Part 15 Radio Frequency Devices

E. National Electrical Manufacturers Association (NEMA):

1. NEMA PE-1 Interruptible Power Systems (UPS)- Specification and Performance Verification

2. NEMA AB-1 Molded Case Circuit Breakers

3. NEMA 250 Enclosures for Electrical Equipment (1000 Volts Maximum)

F. InterNational Electrical Testing Association (NETA):

1. NETA ATS Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

G. National Fire Protection Association (NFPA):

1. NFPA 70 National Electric Code

2. NFPA 110 Standard for Emergency and Standby Power Systems

H. Underwriters Laboratory, Inc. (UL):

1. UL 924 Standard for Emergency Lighting and Power Equipment

2. UL 1778 Standard for Uninterruptible Power Systems

I. Telecommunications Industry Association (TIA):

1. TIA-232 Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange

2. TIA-485 Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems

1.06 WARRANTY

A. UPS: The warranty shall be for 24 months after Acceptance and shall include all costs for repair, parts, labor, travel and living expenses for the manufacturer's service personnel. Under conditions where the UPS is determined to be

unrepairable, the manufacturer shall replace it with a new UPS with comparable specifications.

B. Refer to Section 26 33 01, DC Batteries for warranty on batteries.

C. The manufacturer shall dispatch the technician(s) within 72 hours after the warranty call is requested.

1.07 QUALITY ASSURANCE AND QUALITY CONTROL

A. Manufacturer Qualifications: Company specializing in UPS equipment with a minimum of five (5) years experience in the design, manufacturing, and testing of the UPS systems.

B. Factory Testing: The manufacturer shall fully and completely test the system to assure compliance with the specifications, before shipment.

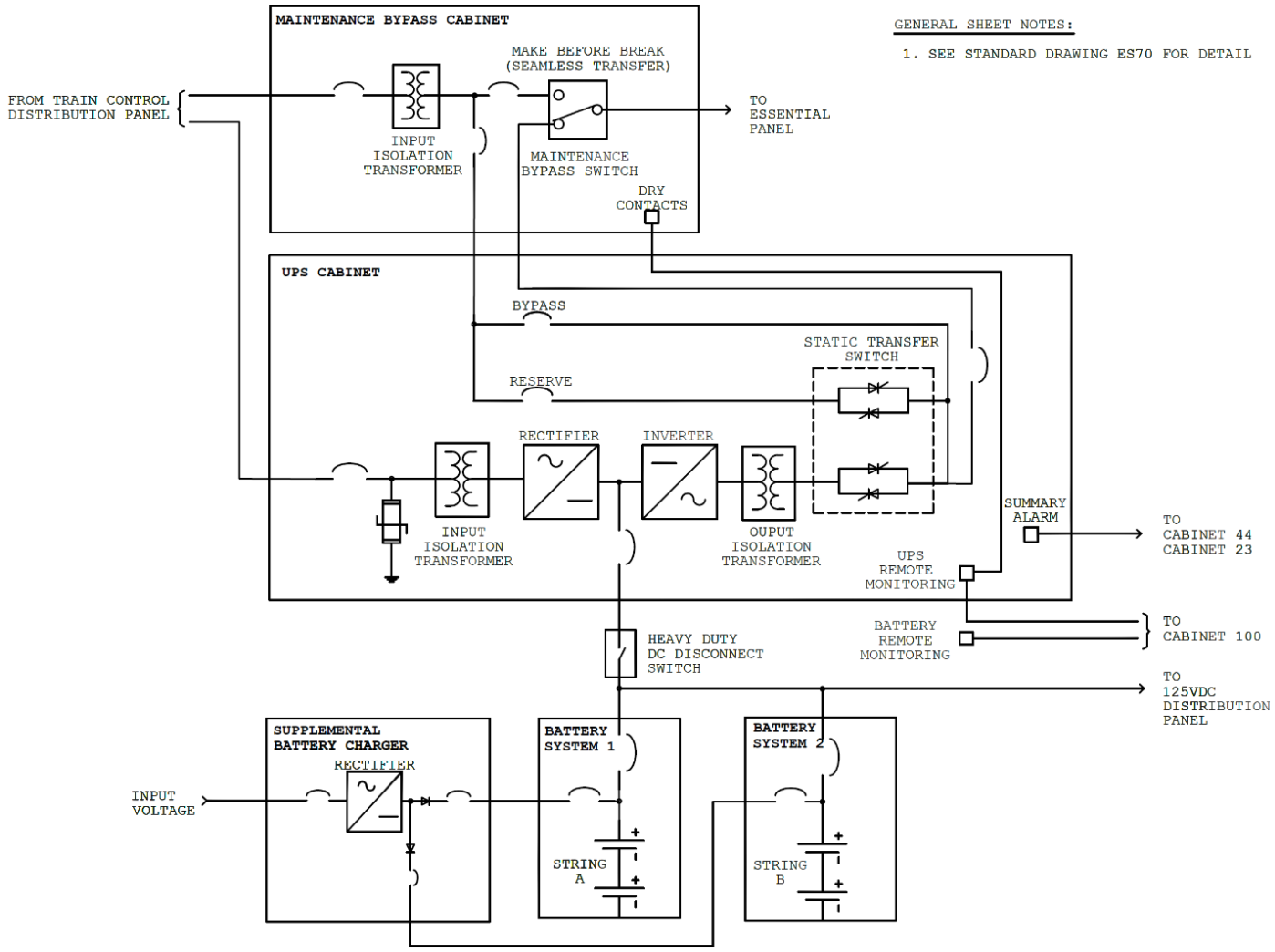


Figure 1: Typical Train Control UPS System Single-Line Diagram

PART 2 – PRODUCTS

2.01 SYSTEM REQUIREMENTS

A. General:

1. The UPS system shall consist of the UPS cabinet, isolation transformers, maintenance bypass cabinet (MBC), static transfer switch, battery assembly and the other features described in the specifications and shown on block diagram Figure 1.

2. UPS Equipment shall be provided by one manufacturer.

3. Testing of UPS Equipment is to be conducted at the Jobsite with the UPS systems fully assembled.

B. Modes of Operation**:**

1. UPS

a. The UPS shall be an on-line type and make-before-break operation during load transfer.

b. **Normal operation:** Under normal operation the power shall be transferred through the UPS converter systems. The output AC voltage shall be fully regulated; the output shall be isolated from the input through an isolation transformer.

c. **Loss of normal input power:** Upon loss of input AC power, there will be no interruption of power as the UPS inverter shall continue to power the load from stored battery system's DC bus. The battery shall continue to supply power to the inverter at rated full load for the specified time as indicated.

d. **Return of Normal Power:** The UPS system shall automatically return to normal operation as described in (b) with no interruption to essential loads. The transfer to normal utility power will be initiated only after ascertaining stable return of input AC voltage after several cycles.

e. **UPS internal fault:** When there is failure in the UPS inverter or the battery system unable to supply power, a control signal shall inhibit the inverter operation and the power will continue to be transferred from input AC to the output through the static bypass switch as indicated in Figure 1.

f. **UPS replacement/maintenance:** In the event the UPS needs to be replaced, the input external bypass switch shall be closed and output disconnect switch shall be opened manually. This will allow total bypass of the UPS for safe removal as indicated in Figure 1.

g. **Operation without batteries:** If the battery is taken out of service, the UPS shall continue to function from the input AC source through static bypass or external mechanical bypass switch.

C. **Power Rating:**

1. The UPS shall be sized in accordance with the District-approved power calculations to support the connected load with a minimum of 20 percent margin of UPS rating. The input line voltage, load voltage, and input bypass line voltage shall be as indicated.

2. The UPS battery shall have capacity as indicated.

D. **Electrical Requirements:**

1. Acoustical Noise: 65 dBA max, measured at 1 meter from the nearest surface of the cabinet.

2. EMI Suppression: Comply with FCC rules and regulation 47.

3. Electrostatic Discharge (ESD): The UPS shall withstand up to 25KV without damage and with no disturbance or adverse effect to the critical load.

4. Efficiency: 80 percent minimum at 50 percent load.

5. Input Surge Protection: Comply with IEEE/ANSI C62.41.

6. Short Circuit Current Rating: UPS shall have 65KA short circuit withstanding rating.

E. **Input Ratings:**

1.	Input voltage:	As indicated.
2.	Input Voltage Range:	+15 percent to -15 percent
3.	Input Frequency Range:	53 to 67 Hz
4.	Phase Unbalance:	The UPS shall not be impacted by input line phase unbalance up to plus or minus 10 percent. The output phase unbalance shall not be contributed by the UPS inverters.
5.	Power Factor:	0.8
6.	Current Limit:	125 percent full load maximum
7.	Protection:	The unit shall be self protected against unwanted over-voltage including line over-voltage and transients such as switching surge and lightning, over-current including short circuits as indicated in Figure 1.
8.	Inrush current:	Soft start shall be used to limit no more than 1.5 by full load for a duration not exceeding 100 milliseconds.

9. Input Transformer: Delta: Y Shall be electrically isolated and copper windings.

10. Isolation: Input shall be isolated from the AC system by an isolation transformer as indicated. The isolation voltage of the transformer shall be per applicable standards.

11. Total Harmonic Distortion (THD): less than 5 percent

F. **Output Rating:**

1. Output Voltage Rating: As indicated.

2. Output Power Rating: As indicated.

3. Output Voltage Regulation: Within plus or minus 2 percent of output voltage

4. Output Frequency: Nominal 60 Hz, plus or minus 0.5 Hz

5. Load Response: 1 millisecond

   a. Free running stability: Plus, or minus 0.15 percent in 24 hours

   b. Stability: Plus or minus 1 percent in 6 months

6. Voltage Transients:

   a. Voltage transient shall not exceed plus or minus 5 percent for any change in load.

   b. Return of AC Power: Plus or minus 2 percent

   c. Manual transfer of load: Plus or minus 5 percent

   d. Automatic transfer of load shall have transient suppression network as well as suppressors.

7. Voltage transient recovery time within 2 percent within 1 millisecond.

8. Load power factor: 0.8 lagging to 0.8 leading

9. Total Harmonic Distortion (THD): less than 3 percent RMS maximum; less than 2 percent any single harmonic

10. Overloads: 125 percent for 10 minutes; 115 percent for 1 hour

11. Static transfer: 1000 percent full load for 1 switch loading cycle; 200 percent full load for 5 minutes

12. Hours of operation: 8 hours for train control and communication loads, 90 minutes for the emergency lightings, and other BART facilities as indicated.

13. Output Transformer:	Secondary Y configuration shall be electrically isolated and copper windings
14. Maximum cabinet size:	As indicated.
15. Phase unbalance:	100 percent (e.g. Phase A-10 percent, phase B-80 percent, phase C-10 percent)

G. **Controls Design and Operating Characteristics:**

1. Fully automatic operation of each UPS module shall be provided through the microcontrollers.

2. Operating and protection parameters shall be firmware controlled to minimize the need for manual adjustments. Adjustments and calibrations shall be performed once at production and at any time the operational parameters are modified. Replacement circuit boards shall be provided with minimum calibration requirements.

3. Start up and transfer shall be automatic functions.

4. Multiple microcontrollers shall be used per module.

5. Configurations, setup, and calibration information shall be stored in non volatile memory.

6. Emergency transfer to bypass due to UPS module failure shall be independent of control logic controlling the rectifier/charger, inverter, and monitor panel.

7. Monitoring and communication logic shall be independent of rectifier/charger and inverter control logic. Circuitry and firmware required for monitoring and communications shall be functionally isolated from the bypass, rectifier/charger, and inverter controls. Monitoring firmware shall be field upgradeable.

8. The UPS module shall be programmable to optionally provide automatic restart capability following loss of utility and complete battery discharge. When utility power returns, the UPS module shall automatically energize the output terminals and subsequently transfer to normal operation.

9. The UPS module shall be able to accept dry contacts and RS-485 signals. The UPS module shall be programmable to deactivate the battery charging upon receiving external signals, including but not limited to exhaust fan failure, hydrogen detected, and high temperature. Discharging from battery system to UPS inverter shall still be active while the battery charger is deactivated.

10. The IP addressable Ethernet (TCP/IP) and parameters shall be made available both locally and remotely. The remote Ethernet (TCP/IP) interface shall be for remote monitoring purposes.

11. IP Addressable Remote Interface:

    Remote signals I/O (Input/Output) signals shall interface with Ethernet (TCP/IP). The remote monitored signals shall be as follows:

    a. Input current

    b. Input voltage (line-line, line-neutral)

    c. Output current

    d. Output voltage (line-line, line-neutral)

    e. UPS fault

    f. Low battery voltage

    g. Low battery shut down

    h. Input AC power failure

    i. UPS on static bypass mode

H. **Environmental Requirements:**

The UPS shall withstand any combination of the following external environment conditions without operational degradation.

1. Operating temperature: 32 degrees to 120 degrees Fahrenheit (0 degrees to 50 degrees Celsius)

2. Relative Humidity: 0 percent to 95 percent non condensing (operating and storage)

3. Elevation: 1000m above mean sea level without derating

I. **Reliability and Maintainability:**

1. The calculated MTBF for the UPS shall be no less than 150,000 hours.

2. Power cables to power transformer and chokes shall be secured with permanent cold weld crimps, that require no maintenance or periodic retorquing.

3. Maintainability: Mean-time-to-repair (MTTR) shall not exceed one (1) hour, including the time to diagnose the problem and replace the sub assembly.

J. **Manuals:**

1. Refer to Section 01 78 23, Operation and Maintenance Data for requirements.

2. Manuals shall include:

    a. Clear and permanent identification on the outside of the binder

    b. Detailed index

c. Documentation to be 8 ½-inch by 11-inch format

d. List of supplier and authorized service representatives for the equipment and accessories supplied. Provide names, address and phone numbers

e. Warranty details

f. List of recommended spare parts

g. Step by step start up and shut down procedures

h. Troubleshooting summary

i. Itemized maintenance schedule for daily, weekly, monthly and yearly maintenance

j. Parts summary including make, model and part number

k. Dimensioned general arrangement drawings

l. Parts diagram and assembly drawings to permit tear down maintenance and/or repair

3. Documentation for purchased components not manufactured by the manufacturer.

4. Manuals for software shall include installation specific or proprietary software necessary to maintain, reload or modify the system. Include latest hard copy and soft copy of software.

2.02 EQUIPMENT REQUIREMENTS

A. General

The UPS shall be designed to operate in a non air conditioned room environment with temperature extremes of 32 degrees Fahrenheit and 120 degrees Fahrenheit (0 to 50 degrees Celsius) and humidity 0 percent to 95 percent non condensing. The UPS circuit shall be of modular design for ease of replacement. The system shall have the capability of remote management and monitoring.

1. Modules shall be standardized such that least replaceable unit (LRU) modules shall fit in the same slot without any need of modifications.

2. Removal of critical components shall be easily accessible for maintenance. Critical components shall be configured for self-diagnosis. LED indicators shall light up and alert technician to system faults. Serviceable parts shall be designed to physically separate high voltage areas to assure safety of maintenance personals.

3. The UPS system shall include sub systems as indicated in Figure 1. This shall include the control protection and monitoring circuits. Any deviation from these specifications shall require BART Engineering’s approval.

4. High stress, high voltages electronics switching components shall be plug and play for the ease in service and maintenance.

5. The cooling fans shall be able to replace easily. Upon detection of the cooling fans failure, audible alarms to be sounded and visual alarms to be displayed on the UPS control panel. Fan failure and alarms shall be shown on the remote monitoring system also.

B. **Rectifier/Charger:**

1. The rectifier/charger shall convert incoming AC power to regulated DC output for supplying the inverter and for charging the battery bank. The rectifier shall be twelve-pulse system with silicon-controlled rectifier (SCR) design or insulated-gate bipolar transistor (IGBT) design. The modular design of the UPS module shall permit easy removal of rectifier/charger without removal of any other assembly.

2. The rectifier/charger shall automatically boost the charge to the battery after battery is drained. The boost charge shall allow a quick recharge and keep batteries in good condition without providing a constant float charge. It shall provide a controlled charging and load exercising of batteries to avoid battery deterioration. Controlled charging of the batteries shall prevent boiling and dehydration of electrolyte. Load exercising of the batteries shall keep batteries continuously cycled, alleviating cell deterioration. To prevent overcharging the boost charge shall stop when ambient temperature could cause damage to the batteries.

3. The charger shall be able to recharge the fully discharge battery to 95 percent state of charge (SOC) in 18 hours.

4. The charger unit shall be programmable and expandable for additional battery modules as indicated.

5. The rectifier/charger shall be furnished with output filtering to limit the ripple currents into the battery.

C. **Inverter:**

1. The inverter shall be high frequency switching converter that implements insulated-gate bipolar transistor (IGBT) technology. The inverter shall have the following features:

   a. The inverter shall be capable of providing the specified quality output power while operating from any DC voltage source (rectifier or battery) within the specified range.

   b. The modular design of the UPS shall permit easy removal of each phase of the inverter and DC electrolytic capacitors without removal of any other assembly.

2. The inverter shall have necessary input/output filtering and circuit for regulation, protection, and monitoring.

3. The DC input of the inverter shall have banks of filter capacitors. The loss of one bank shall not disrupt output voltage or a continued full load operation.

4. Protection:

    a. The inverter output shall be protected against over current (OC) and shall have current limiting circuit.

    b. The inverter input shall have surge protection.

    c. The inverter shall have an active soft start circuit to ramp up to full output voltage within 1 second.

    d. The circuitry shall automatically synchronize and phase lock the inverter output to the alternate power source as long as the source is within plus or minus 0.5 at 60 Hz. If the alternate source is not within these limits, then the inverter shall lock to an internal oscillator.

    e. The inverter shall automatically turn off at the DC voltage low level of 1.75 volts per cell.

    f. Test points and LEDs shall be provided to facilitate adjustments, diagnostics, and identify circuit integrity.

    g. It shall be possible to test logic circuitry without operating the power circuits.

D. **Internal Bypass (Static Transfer Switch):**

The bypass shall serve as an alternate source of power for essential loads when a failure prevents operation in normal mode. A static transfer switch consisting of silicon-controlled rectifier (SCR) shall be provided for automatic/manual transfer of loads from the inverter to the alternate power source. The static bypass switch shall only be required for controlling make before break transfer. The operation of the transfer switch shall be as follows:

1. Uninterrupted transfer to static bypass shall be automatically initiated for the following conditions, at the same time turning off the inverter. The transfer shall be inhibited, if the alternate power source is not within specifications.

    a. Inverter under-voltage

    b. Inverter over-voltage

    c. Inverter overload

    d. Inverter cabinet over temperature conditions

    e. Total battery discharge

    f. UPS module failure

    g. Manual initiation

2. Retransfer to Inverter: The static transfer switch shall be capable of automatically retransferring the load back to the inverter after the inverter has returned to normal operating conditions. Uninterrupted automatic retransfer shall take place whenever the inverter is capable of assuming the critical load.

3. Uninterrupted automatic retransfer shall be inhibited for the following conditions

    a. UPS module failure

    b. In the event of multiple transfer-retransfer operation of the control circuitry shall limit to three operations in any 10 minute period. The fourth transfer shall lock the critical load to the bypass source.

4. Transfer and re-transfers shall be inhibited for the following conditions

    a. Frequency out of limits by plus or minus 0.5 Hz

    b. Bypass out of synchronization

    c. Bypass phase rotational/installation error

5. The bypass shall be manually energized with a breaker internally mounted. No additional control logic shall be required.

6. The control circuitry required to perform an emergency transfer to bypass shall operate independently from the inverter control circuitry.

7. The rectifier/charger input circuit breaker shall have no effect on bypass operation.

8. Over current protection: Fuses shall be placed in the inverter input of the static transfer switch of both sources.

9. Surge protection: The static transfer switch shall have surge protection on the alternate source side.

E. **External Maintenance Bypass Cabinet (MBC):**

1. A manually operated bypass switching arrangement shall be provided to permit transferring the essential loads to the alternate power source, without interruption of power and at the same time to electrically isolate the UPS.

2. The manual bypass switch shall be electrically interlocked to prevent, back feeding the UPS output in the event of incorrect operation, e.g. transferring the load to bypass switch when the load supplied by the inverter.

3. UPS shall initiate an audible alarm upon the transfer to manual bypass. The alarm shall continue to sound while in bypass mode. This shall provide reminder to the user that load continues to be powered from utility or generator supply alone. The audio alarm shall be capable of being muted by the user. The UPS shall have indicator light that shall remain lit even if the alarm is muted when the UPS is in bypass mode.

4. The MBC input and output shall have transient surge protection.

5. MBC shall have the following:

    a. Cabinet Type: NEMA 1, unless otherwise noted

    b. Input AC Voltage: As indicated

    c. Output AC Voltage: As indicated

    d. Cooling: Natural convection with louvers

    e. Input/Output Connections: Terminal blocks

    f. Warranty: Same as UPS

F. **Batteries:**

Batteries, battery racks/enclosures, and accessories shall be in accordance with the requirements specified in Section 26 33 01, DC Battery System.

1. **Battery testing:** The UPS shall perform automatic battery test once a week and allow for user remote and local access to selected battery tests. The test shall not compromise the output of UPS system and alert users through a local and remote monitoring system of any battery error.

2. **Battery contactor:** The UPS shall contain a two pole contactor for disconnecting the battery from the rectifier output and Inverter input. A contactor enabled switch shall be located on the UPS module control panel. With the UPS module in bypass mode, the contactor shall permit the rectifier, inverter, DC capacitors and associated boards to be safely serviced without opening an external battery breaker.

3. **Battery Management System:** The UPS shall contain a battery management system that has the following features:

    a. The battery management shall provide battery time available, or percent remaining, while operating in normal mode and battery mode. Battery time available shall be displayed in real time, even under changing load conditions. The battery time available information shall be within plus or minus 3 percent.

    b. The battery management system shall automatically analyze the UPS battery during a user defined periodic test. During the test, rectifier/charger shall not de-energize, but shall share load with the battery. For remaining battery time information, the battery shall test under the same load for each user defined periodic test. If the battery is weak or defective, the battery management system shall detect and annunciate the battery failure condition without transferring the critical load to the bypass.

    c. The periodic test performed by the battery management system shall not remove more than 10 percent of the available run time from the battery. The periodic test, if performed monthly basis, shall not reduce overall battery life.

d. If the utility outage occurs while a test in progress, the test shall be discontinued, and subsequently conducted at the next programmed interval. The occurrence of the test shall be user programmable for day, date, and time.

e. The battery management system shall record and display the pass/fail status, battery voltage, and indicator value of previous 30 periodic tests.

f. The battery management system shall annunciate a user programmable battery time remaining warning when the UPS is on the battery power.

g. The battery management system shall provide an imminent shut down alarm to signal a low battery condition.

h. The battery management system shall work with either wet cell batteries or valve regulated batteries.

i. The battery management system shall only place a charge on the batteries when the system detects a low battery condition or once a month (programmable). Charging and cycling in conjunction with the rectifier to cycle the batteries and preserve the life of the batteries.

j. Charging current and time fully programmable.

G. **Wiring Terminals:**

1. The UPS shall contain mechanical ratcheting compression terminals adequately sized to accommodate 75 degrees Celsius wiring for securing user wiring to the following locations:

   a. Rectifier/charger connections

   b. Bypass connections

   c. DC link connections

   d. AC output connections

   e. Transformer connections

H. **Controls:**

The UPS system shall be furnished with the following controls on or inside the UPS module cabinet.

1. Rectifier/Charger

   a. Input non-automatic disconnect

   b. DC float voltage adjustment

   c. DC boost (equalize) voltage adjustment

   d. Boost (equalize) voltage timer adjustment

   e. Boost (equalize) voltage initiation

f. Boost (equalize) voltage timer reset

2. Inverter

a. Inverter start

b. Inverter stop

c. DC under-voltage shut off adjustment

d. Output AC voltage adjustment

3. Static transfer switch

a. Transfer switch test

b. Transfer switch setting adjustment

c. Maintenance transfer switch

I. **Metering:**

The following parameters shall be individually metered with a digital read out and with an accuracy of 2 percent or better:

1. DC voltage, Rectifier/charger

2. Direct current: Rectifier/charger

3. AC voltage

a. Input

b. Output

4. Alternating current

5. Inverter

6. Alternate power source

7. Load

8. Frequency

J. **Indicators:**

1. **Monitoring components:** The following components shall provide monitor and control capability

a. Micro-controller driven circuitry

b. Monitor panel with status indicators

c. Alarm and metering display

d. Various communication ports

2. **Monitor Panel Indicator:** The UPS module shall be equipped with a monitor panel providing the following monitor functions and indicators. Each alarm and notice condition shall be accompanied with an audible alarm.

   a. **NORMAL:** This indicator shall be lit when the UPS module is operating in Normal mode.

   b. **BATTERY:** This indicator shall be lit when the UPS module is operating in Battery mode. The Normal Indicator remains lit.

   c. **BYPASS:** This indicator shall be lit when the UPS module is operating in Bypass mode. The critical load is supporting by the Bypass source. The Normal indicator shall not be lit when UPS is in Bypass mode.

   d. **NOTICE:** This indicator shall be lit when the UPS module need attention. Some notices may be accompanied by an audible alarm. Notice shall include:

      1) Bypass not available

      2) Battery under voltage

   e. **STANDBY**: This indicator shall be lit when electricity is present in the rectifier and inverter. The normal indicator shall not be lit. During the start up this indicator remains lit until the UPS transfer to normal mode, at which time the normal indicator shall lit. During the shutdown the standby indictor shall remain lit until all the energy in the UPS module is dissipated and shut down is complete.

   f. **ALARMS:** This indicator shall be lit when the UPS module need immediate attention. Alarms in the form of flashing displays, shall be provided for the abnormal conditions specified below. Auxiliary contacts shall be provided for each abnormal condition as well as a summary alarm contact for connection to SCADA. Circuitry shall be provided for one TIA-232 and one TIA-485 communication port. Provide one Ethernet (TCP/IP) I/O Base T, RJ45 connection for remote monitoring. The system shall be IP enabled. Alarm contacts shall latch until reset.

      1) Low battery voltage and check battery

      2) Over-temperature in the battery enclosure area

      3) DC over-voltage

      4) DC ground

      5) Alternate power source (internal bypass)

      6) Static transfer switch position (in alternate power source)

      7) Fan failure

      8) Maintenance transfer switch position-ON (MBC external bypass)

      9) Battery carrying the load

   g. **ALARM SILENCE BUTTON:** Display panel shall include alarm reset button. If the alarm reset button is pressed for 1 second, the current audible alarms

shall be disabled. If a new alarm occurs, or a cancelled alarm condition disappears and re-appears, then the audible alarm shall be re-enabled.

h. **AUTOMATIC MESSAGING SYSTEM:** A means shall be provided to generate automatic dial signal for telephone and other messaging in the event of input AC power failure to UPS and a failure of the UPS itself.

K. **Enclosure:**

1. Rectifier/charger, inverter, filtering, surge protection shall be installed in NEMA 1 cabinet.

2. The enclosures shall be designed for industrial applications in accordance with the environments requirements. The enclosures shall line up and match up in style and color.

3. Ventilation: The UPS shall be design for forced air cooling. Air inlets shall be in the lower front. Air outlet shall be in the as specified in the contract documents such as rear or the top. Twelve inches of clearance over the UPS air outlets shall be required for proper circulation. Air filters for the UPS shall be commonly available sizes and shall be easily removable from the base.

4. No back or side clearance shall be required for any enclosure. The back and side enclosure covers shall be capable of being located directly adjacent to a wall.

5. Cooling Fans: The modular design to the UPS module shall permitted removal of each fan without the removal of any other assembly. Fan replacement shall be accomplished by removing no more than one fastener per fan and shall not require the removal of another sub assembly.

6. Cable entry: As specified in the contract documents such as top, bottom or side. A dedicated wire way shall be provided within the UPS for routing user input and output wiring. All wiring compartment to meet NFPA 70, NEC size requirements for cable turning radius.

7. Front Access: Serviceable equipment shall be modular and capable of being replaced from the front of UPS. Side or rear access to UPS module shall not be required for UPS installation, service, repair, or maintenance.

PART 3 – EXECUTION

3.01 FIELD QUALITY CONTROL AND COMMISSIONING

A. The following test shall be performed by the field service personnel during the UPS start up:

1. **Visual inspection:**

a. Visually inspect equipment for signs of damage and foreign materials.

b. Observe the type of ventilation, cleanliness of room, the use of proper signs, and any other safety related factors.

2. **Mechanical inspection:**

a. Check all the power connections for tightness.

b. Check all the control wiring terminations and plugs for the tightness or proper seating.

3. **Electrical pre check:**

a. Check the DC bus for the possible short circuit.

b. Check the input and the bypass for the proper voltage and phase rotation.

c. Check all test functions.

4. **Initial Start up:**

a. Verify that all the alarms are in a go condition.

b. Energized the UPS module and verify the proper DC, walkup, and AC phase on.

c. Check the DC link voltage, AC output voltages, and output waveform.

d. Check the final DC link voltage and inverter AC voltage output. Adjust if required.

e. Check for proper synchronization.

f. Check the voltage difference between the inverter output and bypass source.

B. The UPS power equipment manufacturer/Supplier representative shall be an integral part of the project commission team. The UPS power equipment representative shall attend the regular schedule commissioning meetings to assist in start up scheduling and resolve system installation conflicts prior to actual start up.

3.02 TRAINING

A. Refer to Section 01 79 00, Demonstration and Training for requirements.

3.03 SPARE PARTS LIST

UPS supplier shall provide a recommended spare parts list.

END OF SECTION 26 34 37

SECTION 26 42 00

CATHODIC PROTECTION

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Cathodic protection rectifiers.

B. Impressed current anodes.

C. Anode shunt junction box.

D. Bonding boxes.

E. Terminals and terminal blocks.

F. Insulating flange kits.

G. Sacrificial anodes.

H. Cathodic protection and bonding cables.

I. Test stations.

J. Nameplates, nameplate bar

K. Accessories

1.02 RELATED SECTIONS

A. Grounding and bonding requirements and procedures are specified in Section 26 05 26, Grounding and Bonding for Electrical Systems.

1.03 MEASUREMENT AND PAYMENT

A. General: Cathodic protection, as specified herein, will not be measured separately for payment but will be paid for as part of the Contract lump-sum price for Electrical Work as indicated in American Society for Testing and Materials (ASTM):

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM D1248 Specification for Polyethylene Plastics Molding and Extrusion Materials

2. ASTM D3032 Test Methods for Hookup Wire Insulation

B. Institute of Electrical and Electronics Engineers, Inc. (IEEE):

1. IEEE 316 Requirements for Direct Current Instrument Shunts

C. National Association of Corrosion Engineers (NACE):

1. NACE RP0169 Control of External Corrosion on Underground or Submerged Metallic Piping Systems

D. National Electrical Manufacturer's Association (NEMA):

1. NEMA AB 1 Molded Case Circuit Breakers and Molded Case Switches
2. NEMA ICS 6 Industrial Control and Systems Enclosures
3. NEMA ST 1 Specialty Transformers (Except General-Purpose Type)
4. NEMA WC 5 Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy the Bid Schedule of the Bid Form.

1.05 SUBMITTALS

A. Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Submit the following submittal information and documents:

1. Schematics and interconnecting drawings;
2. Connection diagrams and outline drawings;
3. Assembly, erection, and installation drawings and manuals;
4. Manufacturer's product and performance data;
5. Operations and maintenance manual for the cathodic protection system;
6. Certificates of Compliance, as required;
7. Test reports; and
8. Parts and special tools lists.

PART 2 – PRODUCTS

2.01 CATHODIC PROTECTION RECTIFIERS

A. Rectifiers shall be provided with a minimum of 20 even adjustments, with conveniently accessible taps over the full voltage output range.

B. The efficiency of each rectifier shall be at least 70 percent. Each rectifier shall be complete with enclosure, transformer, voltage control taps, and necessary appurtenances. Voltage, phase, ac input, and dc output ratings shall be as indicated. The enclosures shall be in accordance with NEMA ICS 6. Sunshades shall be provided for each outdoor rectifier.

C. Rectifiers shall be enclosed in sheet metal enclosures with welded seams. The enclosures shall be provided with hinged doors. Circuit breakers, ammeters, and voltmeter shall be mounted on an inside panel. The rectifier shall have a ground lug for a minimum of 2/0 AWG ground wire, or as indicated, and shall be suitable for wall or post mounting, with knockouts provided for conduit entrance.

D. Rectifier semiconductors shall be high current silicon diodes.

E. Silicon diodes shall be rated to provide adequate margin for over-voltage and over-current surges. They shall be mounted on a heat sink designed to maintain junction temperatures well below manufacturer's recommended maximum temperatures when operating in a 122 degrees F ambient. The rectifier stack shall be single-three-phase, full wave, bridge connected. Silicon diodes shall be protected on input and output sides with zener type selenium surge plates and lightning arrestors.

F. The transformer shall be a two-winding type with 428 degrees F insulation to operate at rated kVA with a temperature rise not exceeding 270 degrees F above a 122 degrees F ambient. The secondary winding shall have a minimum of four coarse and five fine voltage control taps to provide adjustable output voltages in equal steps over the entire operating range. Voltage control taps shall be stud and link type with removable nuts. The studs and links shall be rated to carry 125 percent of the rectifier full load current. The transformers shall conform to NEMA ST 1.

G. Each rectifier unit shall have internally mounted meters to read dc current and dc voltage. The ammeter shall be provided with an external shunt. The meters shall be red lined at approximately the three-quarter point of the rectifier unit "full scale" rated value. The meters shall have an accuracy of plus or minus 2 percent.

H. The main circuit breaker shall be molded case, trip free, flush mounted with toggle handle readily accessible. An overload or short circuit through any single pole shall open all poles simultaneously. The circuit breaker shall conform to NEMA AB 1.

I. Fuses of the nonrenewable type shall be installed in the secondary side of the rectifier and shall be mounted on the front of the rectifier panel. All wiring shall be in accordance with Section 20 70 26 - Common Materials and Methods for Electrical systems, and Section 26 05 24 - Low Voltage Wires and Cables.

2.02 IMPRESSED CURRENT ANODES

A. High silicon iron chromium anodes shall have the following mineral analysis:

	Element	Percent
1.	Silicon	14.5
2.	Manganese	0.75
3.	Carbon	0.95
4.	Chromium	4.5
5.	Iron	remainder

B. For underground piping, the anode shall be high silicon iron chromium, prepackaged in steel canisters. Backfill as specified herein shall be compacted to fill the container. The container top shall be perforated. A strap shall be designed and installed that will support the weight of the package. Container size shall be 22 gage, 10 inches in diameter, 7 feet long.

C. For underground piping, the anode lead wire shall be protected by a compression washer and a bushing at the top of the container. Anodes shall be provided with epoxy-encapsulated heads with heat-shrink caps. Anode locations and lead wire lengths shall be as necessary.

D. For underground piping, anode backfill material shall be a tamped calcined coke breeze, screened to provide a particle size from 1/8 inch to 3/8 inch. Resistivity shall not exceed 25 □/cm at a moisture content of 1 percent and a bulk density of 46 to 50 pounds per cubic foot. Composition shall be within the following limits:

	Material	Typical	Guaranteed
1.	Fixed carbon, percent (dry basis)	99.4	99.0 min
2.	Ash, percent (dry basis)	0.3	0.5 max.
3.	Volatile matter, percent (dry basis)	0.3	0.5 max.
4.	Sulfur, percent (dry basis)	0.8	1.2 max
5.	Moisture (per Cent)	0.02	1.0 max.

2.03 ANODE SHUNT JUNCTION BOX

A. The enclosure shall be a watertight galvanized steel box complete with terminal blocks, shunts, copper jumpers, and bus bars. Box shall be coated, non-metallic, as approved by the Engineer.

B. Shunts shall be 0.01 Ω, 8 A, if high silicon iron chromium anodes are used.

2.04 BONDING BOXES

A. The enclosure shall conform to NEMA ICS 6. Shunts, terminal blocks, and bus bar shall be mounted on the backplate.

B. Hookup wiring shall be thermoplastic flame retarding in accordance with ASTM D3032.

2.05 TERMINALS AND TERMINAL BLOCKS

A. Connections shall be made with compression type ring tongue or spring spade (locking spade) terminals sufficiently strong to prevent their breakage under the conditions of vibration for which the equipment is designed.

B. The dc output terminal shall be sized for not less than No. 2 AWG cable. Slotted, flanged spade and hook terminals or terminals of the quick disconnecting type are not acceptable. Crimping tool and terminal blocks shall be provided as necessary. Insulated ferrules shall be provided if adjacent cable terminations permit contact.

2.06 INSULATING FLANGE KITS

A. Insulating gaskets for service up to 175 degrees F shall be ring type, neoprene-faced phenolic. For service up to 250 degrees F insulating gaskets shall be ring type non-asbestos faced phenolic suitable for 250 degrees F.

B. For insulating sleeves, material shall be high-density polyethylene 1/32 inch thick. Sleeve lengths shall be two flange thicknesses, including raised faces, plus gasket thickness, plus two insulating washer thicknesses, plus steel washer thicknesses. Flange bolt holes shall be oversized.

C. Two insulating washers and two steel washers for each sleeve are required. The insulating washers shall be linen electric grade, 1/8 inch thick. The steel washers shall be machine cut, de-burred, and at least 1-1/4 inches in outside diameter by 11 gage.

D. Test bolts shall be 1/2-13 UNC by 2 inches silicon bronze cap-screws.

2.07 SACRIFICIAL ANODES

A. Sacrificial anodes shall be magnesium anodes and shall comply with the following chemical requirements:

1.	Aluminum	0.010 percent (max.)
2.	Manganese	0.50 to 1.30 percent
3.	Zinc	0
4.	Silicon	0

5. Copper 0.02 percent (max.)

6. Nickel 0.0001 percent (max.)

7. Iron 0.03 percent max.

8. Other 0.05 percent max. each or 0.3 percent max. total

9. Magnesium Remainder

B. Anodes shall be cast with a galvanized steel rod core, silver soldered to HMWPE cable, and shall have a net magnesium weight of 20 pounds (Galvomag 20D2). The core weight shall not exceed 0.1 pound per foot.

C. Anodes shall be contained in a cloth sack with 50 pounds of backfill consisting of 75 percent hydrated gypsum, 20 percent bentonite, and 5 percent sodium sulfate.

D. The anode lead wire shall be No. 8 AWG, 600 volt HMWPE insulation.

E. Anode lead wires shall be long enough to permit installation to test stations without use of underground splices.

2.08 CATHODIC PROTECTION AND BONDING CABLE

A. Cathodic protection cables shall be in accordance with NEMA WC 5, high molecular weight (HMW) Type CP polyethylene insulation not less than 7/64 inch thick, with hypalon jacket on anode cables. Insulation material shall be in accordance with ASTM D1248, Type I, Class C, Grade 5. Cables shall have copper stranded conductors, sized as follows:

1. No. 8 AWG for pipe leads to test station boxes.

2. No. 8 AWG from anodes to anode junction boxes.

3. No. 2 AWG for cathodic protection rectifier positive and negative leads to distribution boxes.

4. No. 2 AWG for cast iron pipe mechanical joint bonds.

B. Splicing of underground cables shall be avoided as much as possible. Where splicing is necessary, provide splice boxes. Splicing of cables shall occur in splice boxes only. Necessary splices and repairs shall be made with cast insulating splice kits acceptable to the Engineer.

2.09 TEST STATIONS

A. Two, three, or four-wire test stations shall be provided. The test stations shall consist of a weatherproof terminal box, NEMA Type 3 R, with removable cover, test lead wires, and five terminals, installed approximately 3 feet above the surface.

B. Flush type test stations shall be installed. They shall be approximately 4 inches by 18 inches or 5 inches by 18 inches long plastic pipe with heavy cast-iron loading covers and collars suitable for both curb and roadway installations.

2.10 NAMEPLATES, NAMEPLATE BAR

A. Engraved nameplates and nameplate bars shall be provided conforming to the requirements of Section 20 70 26, Common Materials and Methods for Electrical Systems.

2.11 ACCESSORIES

A. Reference Electrodes: Reference electrodes shall be as indicated.

B. Potential Stations: Potential stations shall consist of a precast concrete housing or vault that is open at the bottom and shall be furnished with a cast iron traffic cover marked CP on the top of the cover. The station shall be filled to within 3 inches of its top with clean soil.

PART 3 – EXECUTION

3.01 WELDING

A. Welding Procedures: Make connections between copper conductors and metallic piping, and other metal components, by either exothermic welding or brazing, except that brazing will not be permitted on natural gas distribution and transmission facilities. Procedures, materials, and equipment for thermite welding shall conform with the manufacturer's printed welding recommendations. Brazing shall conform to AWS standard practices.

B. Thermite Weld: For rectifier negative wires and anode wires, when the thermite weld has cooled and the slag has been removed, the weld shall be tested by striking the weld with a two pound hammer around the weld at an angle of 45 degrees to the surface while pulling on the wire. Remove and replace defective welds with new welds.

C. Protective Coating: Coat welds with cold applied mastic or a coating equal to that on the structure, ensuring that bare or exposed metallic areas are coated. Allow adequate time for drying.

3.02 ANODES

A. Install cathodic protection anodes at the locations and in the manner indicated. Route wires from the anodes so as to prevent damage and mechanical stress on the insulation upon backfilling. Inspect insulation on anode wires for damage and approve before backfilling. Replace anodes with damaged wire insulation. Splicing of anode wires will not be permitted. Installation shall conform to NACE RP0169.

B. Install sacrificial metal anodes at the locations and in the manner indicated. Installation shall conform to NACE RP0169.

1. Wet packaged anode thoroughly before backfilling the hole.

2. Use native soil, free from stones, aggregates, and bricks, for backfilling. Do not use sand or slurry cement for backfill on anodes.

C. Install anode junction and test boxes of types and at locations indicated.

D. Connect anode lead wires to header cable or in test boxes as indicated.

3.03 FIELD QUALITY CONTROL

A. Inspection and testing of work associated with the installation of the cathodic protection system shall be performed by the Contractor under the observation of the Engineer.

B. Provide qualified personnel as required to assist the Engineer in locating the installed test points. Provide as built details of test point installations.

3.04 CATHODIC PROTECTION SYSTEM ACTIVATION

A. Activation and confirmation of the cathodic protection system shall be performed by the Contractor and verified by the Engineer.

B. Anodes shall be tested for proper current output and level of cathodic protection provided to piping systems, after installation of anodes and associated wiring and junction boxes, but before final street paving or construction of concrete sidewalks.

END OF SECTION 26 42 00

SECTION 26 50 00

LIGHTING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Lighting fixtures.

B. Fixture mounting hardware.

C. Lamps.

D. Emergency Lighting.

E. Lighting control equipment.

F. Source quality control.

G. Standard fixtures.

1.02 RELATED SECTIONS

A. Lighting control panel boards (addressable panels) are specified in Section 26 09 26, Lighting Control Systems.

B. Refer to Section 20 70 26, Common Materials and Methods for Electrical Systems, for requirements.

1.03 MEASUREMENT AND PAYMENT

A. Separate measurement and payment will not be made for the Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the Bid Schedule of the Bid Form, or incidental to the Work of the Contract.

1.04 REFERENCES

A. American National Standard Institute (ANSI):

1. ANSI C136 Series Standards for Roadway and Area Lighting Equipment
2. ANSI C82.77-5 Lighting Equipment – Voltage Surge Requirements
3. ANSI/AISC 360 Specification for Structural Steel Buildings

B. American Society for Testing and Materials (ASTM):

1. ASTM A123/A123M Standard Specification for Zinc (Hot-Dip Galvanized) Coating on Iron and Steel Products

2. ASTM A1008/ A1008M — Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low Allow with Improved Formability, Solution Hardened, and Baked Hardenable

C. DesignLights Consortium (DLC)

D. Environmental Protection Agency (EPA)

E. International Dark Sky Association (IDA)

F. Illuminating Engineering Society of North America (IES):

1. IES Lighting Handbook, Reference and Application

2. LM-79 — Optical and Electrical Measurements of Solid State Lighting Products

3. LM-80 — Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays, and Modules

4. TM-21 — Projecting Long-Term Lumen, Photon, and Radiant Flux Maintenance of LED Light Sources

G. Institute of Electrical and Electronics Engineers, Inc. (IEEE):

1. IEEE C62.41.1 — IEEE Guide on the Surge Environment in Low-Voltage (1000 V and less) AC Power Circuits

2. IEEE C62.41.2 — IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and less) AC Power Circuits

H. National Electrical Manufacturers Association (NEMA):

1. NEMA C81 Series — Electric Lamp Bases and Holders

2. NEMA WD7 — Occupancy Motion Sensors Standard

I. National Fire Protection Association (NFPA):

1. NFPA 1 — Fire Code

2. NFPA 70 — National Electrical Code

3. NFPA 101 — Life Safety Code

4. NFPA 110 — Standard for Emergency and Standby Power Systems

5. NFPA 130 — Standard for Fixed Guideway Transit and Passenger Rail Systems

J. Underwriters Laboratories Inc. (UL):

1.	UL 94	Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
2.	UL 496	Standard for Safety Lampholders
3.	UL 508	Standard for Safety Industrial Control Equipment
4.	UL 773	Standard for Safety Plug-In, Locking Type Photocontrols for Use with Area Lighting
5.	UL 916	Standard for Safety Energy Management Equipment
6.	UL 924	Standard for Emergency Lighting and Power Equipment
7.	UL 1598	Standard for Safety Luminaires
8.	UL 8750	Standard for Safety of Light Emitting Diode (LED) Equipment for use in Lighting Products

1.05 REGULATORY REQUIREMENTS

A. Federal Communications Commissions (FCC):

1.	Title 47	Rules and Regulations

B. California Code of Regulations (CCR):

1.	Title 8	Industrial Relations
2.	Title 22	Social Security
3.	Title 24, Part 2	California Building Code
4.	Title 24, Part 3	California Electrical Code
5.	Title 24, Part 6	California Energy Code
6.	Title 24, Part 11	California Green Buildings Standards Code

1.06 SUBMITTALS

A. Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Submit product data including the following:

1. Catalog sheets and specifications

2. Ratings, configurations, wiring diagrams, dimensions, service conditions, options and features

3. Table matrix showing the specification requirement and the product data showing specifications are met

C. Submit Shop Drawings including the following:

1. Single line, schematic, block, and wiring diagrams

2. Equipment layout of lighting system components

3. Plan view details and component topologies

4. Photometric drawings and network riser diagrams

5. Luminaire marking and labeling

D. Installation procedures: Include tools and materials list, mounting templates, and dimensions.

E. Calculations:

1. Lighting photometric analysis shall reference the IES recommended calculations using a lighting software tool. Report shall include the following:

   a. Calculations at L70 and another at initial lumens.

   b. Lighting fixture schedule shall include symbol, quantity, arrangement, lighting loss factor (LLF), manufacturer and luminaire name, luminaire type, wattage, color correlated temperature (CCT), house shield if any, distribution type, color rendering index (CRI).

   c. Calculation areas shall include visible lighting luminaire pattern, area dimensions, and calculation points.

   d. Calculation and statistical summary shall be separate for each area as indicated. Each statistical area shall be highlighted differently.

   e. Rendering view of calculated areas.

   f. Contract number and title, Contractor name, revision, date.

   g. Surface reflectance.

2. Submit details of lighting pole, foundation, and anchorage with supporting loads and structural design calculations.

3. Submit details of luminaire mounting and bracket with supporting loads and structural design calculations.

F. Submit test reports including the following:

1. Certified test reports of factory and field tests performed.

2. Title 24 Acceptance Testing Documentation in accordance to Title 24, Part 6, as indicated.

3. Seismic analysis report.

4. LM-79, LM-80, and TM-21.

5. Testing and Commissioning Testing Results.

G. Manufacturer's certificates: Include certificate ensuring products meet or exceed specified requirements.

H. Submit the operation and maintenance manual, in accordance with Section 01 78 23, Operation and Maintenance Data, including the submittal items mentioned above and the following:

1. Sequence of operation

2. Preventive maintenance procedure

3. Spare parts list and ordering form

4. Troubleshooting guide for common issues

1.07 LABELING

A. Lighting fixtures, light poles, lighting control equipment shall be labeled. Labelling shall be approved by the Engineer.

B. Emergency lighting luminaire shall be identified.

C. Luminaire labeling information shall include panel and circuit number, and contract number.

1.08 NAMEPLATE

A. Mark fixtures clearly with manufacturer's name, voltage, wattage, UL listings.

1.09 DELIVERY HANDLING AND STORAGE

A. Deliver luminaries and lighting equipment to the Jobsite complete with related items, completely wired and assembled.

PART 2 – PRODUCTS

2.01 LIGHT EMITTING DIODE (LED) LIGHTING

A. LED Luminaire

1. LED fixture requirements are as described below:

    a. The LED fixture shall consist of LED lamps, driver, assembly, and mounting hardware.

    b. Each fixture shall have its own LED driver. LED drivers shall be placed within LED fixture, unless otherwise specified.

    c. Input voltage and frequency: 120 VAC to 277 VAC plus or minus 10 percent, 60Hz.

    d. Efficacy: as indicated.

    e. NEMA Rating: as indicated.

    f. Brightness and glare: Lighting systems shall be free from distracting and uncomfortable glare.

    g. Warranty: minimum 5 years.

    h. Cooling System: Cooling system shall not have fans, pumps, or liquids and shall be resistant to debris and dust buildup.

    i. LED fixtures shall be rated for Class I Division II Hazardous Locations, as indicated.

    j. Lens: as indicated.

    k. Shields: as indicated.

    l. LM-80 and TM-21 shall be used to determine lifespan outside L70 controlled lab settings.

    m. Outdoor LED Luminaires shall comply with Title 24 Part 6 – 130.2(b) for luminaire cutoff requirements.

    n. Fixture shall be UL Listed.

B. LED lamp

1. LED lamp requirements are as described below:

    a. Definition: LED lamp Assembly is the LED assembly without LED driver.

    b. Correlated Color Temperature (CCT): 3000K to 3500K indoor, 4000K to 4500K outdoor and tunnels.

    c. Color Rendering Index (CRI): greater than or equal to 80, except for parking lots where it shall be greater than or equal to 70.

    d. Operating hours shall be determined by LM-80 and TM-21. Reported L70 hours shall be minimum 50,000 hours.

    e. Difficult access areas such as on top of escalators and stairs shall have reported L70 of 60,000 hours, minimum.

C. LED Driver General Requirements:

1. LED driver general requirements as described below:

   a. Input voltage: 120 VAC to 277 VAC (plus or minus 10 percent).

   b. Frequency: 60Hz.

   c. Operating temperature: minus 20 degrees Celsius to plus 50 degrees Celsius.

   d. Minimum efficiency: 85 percent.

   e. Driver shall be dimmable.

   f. LED dimmable driver requirements are as described below:

      1) There shall be no visible change in light output with a variation of plus or minus 10 percent line voltage input.

      2) Driver shall provide step-free, continuous dimming from 100 percent to 10 percent; and shall respond similarly when rising from 10 percent to 100 percent.

      3) LED dimming driver shall provide continuous step-free, flicker free dimming over the operating range, with “Fail-Safe” 0 to 10 V dimming standard.

   g. Driver shall be self-protected, including surge protection and short circuit protection and shall comply with ANSI or IEEE standards.

   h. Comply to FCC CFR, Title 47, Section 15.

   i. LED driver shall have a minimum of 50,000 operating hours under warranty.

   j. Power Factor (PF) greater than or equal to 0.90.

   k. Each fixture shall have its own LED driver. LED drivers shall be placed within LED fixture, unless otherwise specified.

2.02 FIXTURE MOUNTING HARDWARE

A. Requirements:

1. Luminaire mounting hardware shall be in accordance to the luminaire manufacturer’s recommended requirements.

2. When exposed to public view, fabricate and finish hardware in material matching the fixture body.

B. Light poles:

1. Provide the type, configuration, and dimensions indicated. Light pole shall resist wind loads in accordance with the California Building Code,. Maximum deflection of pole shall be five percent when fully loaded. Furnish poles as indicated with handhole and flush cover with tamper proof screw and grounding stud, luminaire

mounting tenon/bracket, base cover and mounting hardware including anchor bolts, nuts, washers, and baseplate to permit accurate alignment and installation of pole and luminaire as indicated. Light pole anchor bolt covers shall have tamper proof screw.

2. Light pole ladder and safety cable shall conform to CCR Title 8, Industrial Relations, Division 1, Chapter 4, Subchapter 7, Group 1, Article 4, Section 3277(m), Ladder Safety Systems, and CAL/OSHA.

3. Lowering types pole specifications shall be as follows:

   a. Poles shall be 50 feet galvanized round tapered steel and shall include pole shaft, hand hole, support plate, anchor base, anchor bolts with washers and nuts, and brackets to mount camera box.

   b. The pole shall resist wind loads in accordance with the California Building Code.

   c. Pole shall be equipped with a hand hole with cover plate. Hand hole shall allow adequate clearance for installing, servicing, and maintaining the lowering device system. Hand hole shall include a steel cover plate and shall be sealed and feature covered pulldowns to ensure weather tight protection. The hand shall be lockable for added safety and security. Hand hole rim shall conform to ASTM standards. Designation, Hand hole cover shall conform to ASTM standards.

   d. Base plate, support plate, and anchor bolts shall be per ASTM standards.

4. Lowering device specifications shall be as follows:

   a. Lowering device shall have internal motor with a minimum of 1 hp heavy reversing type electrical motor with a stalled torque at least twice that required to operate the lowering device.

   b. Lowering device shall have internal winch assembly. Lowering device shall consist of spun aluminum copper free cover, cast high strength copper free aluminum latch barrel, stainless steel latch pin, galvanize steel luminaire ring, stainless steel centering spring and steel adjustment nut, stainless steel wire rope grip, on-marking guide arm roller and cast aluminum iris guide arm, junction box and reflection latch indicator.

   c. Lowering device shall be top latching, centering arm unit with an internal winch. Internal drive lowering device shall be able to hold multiple luminaires, 50 foot pole height, stainless steel hoist, winch cable, with camera ready provisions, and with special arm assemblies on frame.

2.03 LIGHTING CONTROL EQUIPMENT

A. Refer to Section 26 09 26, Lighting Control System for lighting control equipment requirements.

2.04 EMERGENCY LIGHTING

A. Emergency lighting system shall be as indicated.

B. Emergency lighting system shall comply with CBC, CEC, UL924, NFPA 101, NFPA 110, and NFPA 130.

2.05 SOURCE QUALITY CONTROL

A. The lighting fixture to be tested shall be typical of the unit it represents, clean and free from mechanical defects, equipped with the proper fittings, and with the lamp of the size and type in the position recommended for service operation.

B. Test UL-listed material, equipment, and components in accordance with UL standards. Test material, equipment, and components not covered by UL standards in accordance with nationally recognized standards. Provide material, equipment, and components bearing a label tag or certification of such inspection.

C. Perform and report tests for photometric performance in accordance with the approved methods outlined by the IES Lighting Handbook for photometric testing, and include data on candlepower, distribution, zonal lumens, maximum luminance values, and luminaire efficiency, including complete coefficients of utilization tables to indicate compliance with performance requirements.

D. Test data shall be reported on 8-1/2 inch by 11-inch sheets and shall be certified by a nationally recognized independent testing laboratory.

2.06 STANDARD FIXTURES

A. Tunnel Fixtures: Provide fixtures that are UL listed for wet locations, and that include the following features, appurtenances, and accessories:

1. Housing shall be 0.125 inch extruded aluminum with anodized finish. Housing upper portion shall have an integral continuous clevis on each side, accommodating a slide grip hanger assembly, eliminating all mounting hole requirements.

2. End caps shall be 0.150 thick cast aluminum with service entry hubs on each end for 1/2-inch conduit. End caps and hub assembly shall be firmly held against the extruded housing and lens by a cast aluminum bracket on each end.

3. Reflector/driver cover shall be of 0.05 inch aluminum and chain hinged for ease of access with baked-on white enamel finish.

4. Provide gasket continuous along the length of lens/housing intersection with one piece 0.250 inch close celled neoprene gasket. Gasket the entire inner wall of each end cap with 0.250 inch close celled neoprene gasket.

5. Provide wall-mounting bracket for 45 degree mounting tilt. Bracket shall be galvanized plate steel and moveable along the entire length of fixture housing. Two brackets per fixture are required.

6. Diffuser shall be of 0.125 acrylic with internal prisms for low brightness and smooth external surface for minimizing dirt collection.

7. Tunnel lighting fixtures and mounting devices shall be designed to withstand air pressure waves ranging from plus 80 psf to minus 80 psf repetitively with each passing train.

B. Emergency Trip Station Blue Light: Provide fixtures that are UL listed for wet locations, and that include the following features, appurtenances, and accessories:

1. Provide housing and outlet box of glass reinforced (30 percent) polyester material conforming to UL 94V-0. Polyester housing and box shall be nonfading, permanent gray color, ultraviolet resistant.

2. Provide blue enclosing globe of heat-resistant glass with integral male threads for mounting into housing with white LED lamp and metal guard.

3. Boxes shall be tapped for 3/4-inch conduit. Plugs shall be of same polyester material. Provide box with mounting ears, as indicated.

4. The blue light shall be composed of two ultra-bright, long lasting LED lamps and shall be visible at any point within 250 feet from its designated mounting location.

5. The blue light LED lamp shall provide a minimum of 750 effective lumens.

C. Operator’s Access Aisle Fixture: Provide fixtures that are UL listed for wet locations, and that include the following features, appurtenances, and accessories:

1. Provide one piece housing of die cast aluminum with integral cooling fins over the optical chamber and electrical compartments and double thick gussets on the support arm-mounting end. Housing shall form a half-cylinder shape with 55 degree front face plane providing a recess to allow a flush single-latch detail. All hardware shall be stainless steel.

2. Provide lens frame and cam-latch of die cast aluminum and mate with 1 inch minimum depth around the gasket flange. Provide integral cast hinges with stainless steel pins that allow removal, without tools, from the housing. Cam-latch shall provide positive locking and sealing of the optical chamber.

3. Provide clear tempered glass lens 3/16-inch thick with one piece molded perimeter gasket seal retained by eight stainless steel clips.

4. Provide reflector assembly of specular alzak aluminum mounted in an aluminum frame attaching to fixture housing as a one piece module. Reflector module shall be field rotatable in 90 degree increments.

5. Provide factory pre-wired electrical module components on a single plate with a socket to a quick-disconnect plug and include a wire seal through the barrier wall. Attach module to housing with no-tool hinges and latches, accessible by opening the lens frame only.

6. Support arm shall be one piece extruded aluminum, fully radiussed internal bolt guides top and bottom and circular cut for specified round pole. Provide luminaire to pole attachment by internal draw bolts and include a pole reinforcement plate with wire strain relief.

7. Provide finish housing, lens frame, latch and support arm with thermoset polyester powder coat paint in natural aluminum color. Components shall be thoroughly cleaned and primed with protective chromate conversion coating prior to powder coating. Powder coating shall be 2.5 mils nominal thickness.

8. Provide LED lamp, 277 VAC.

D. Cross Passage Yellow Light: Fixture shall be identical to emergency trip blue light fixture. It shall be equipped with amber or yellow enclosing globe. Enclosing globe shall be of heat-resistant glass with integral male threads for mounting into housing.

E. Wet Standpipe Valve White Light: Fixture shall be identical to emergency trip blue light fixture. It shall be equipped with white enclosing globe.

2.07 SPARE PARTS

A. General: Refer to Section 01 78 44, Spare Parts and Maintenance Materials, for spare part requirements.

B. Luminaire: Furnish 2 percent of each style of lighting luminaire, or a minimum of 5 each, whichever is greater.

C. Light Poles: Furnish 1 percent of each style of light pole assembly, or a minimum of 2 each, whichever is greater.

PART 3 – EXECUTION

3.01 INSTALLATION OF LIGHTING FIXTURES

A. Install lighting fixtures as indicated and in accordance with the manufacturer’s installation instructions and recommendations, complete with lamps, hangers, brackets, poles, fittings, and accessories, ready for operation.

B. Align, mount, and level lighting fixtures uniformly.

C. Avoid interference with, and provide clearance for, the equipment. Where the indicated locations for the lighting fixtures conflict with the locations for other equipment, change the locations for the lighting fixtures by the minimum distances necessary and as approved by the Engineer.

D. For suspended lighting fixtures, provide the indicated mounting height clearances between the bottoms of the fixtures and the finished floors.

E. Anchor lighting fixture supports to the structural slab or to structural members as indicated. Supports shall maintain the fixture positions after cleaning and re-lamping. Provide supports for seismic loading in accordance with applicable requirements of the California Building Code and the California Electrical Code.

F. Surface-mounted lighting fixtures shall be bracketed rigidly from the mounting surfaces. Provide 1/4-inch clearance between surfaces when the fixture is flat- mounted against concrete surfaces. Install fixtures with a non-cumulative dimensional alignment tolerance of 1/16-inch when mounted in continuous runs with one inch spacing between individual fixtures. Nipples carrying wires between fixtures shall be watertight.

G. Where aluminum is placed in contact with dissimilar materials, except galvanized steel, zinc, and stainless steel, treat contact surfaces as follows:

1. Dissimilar metals: Apply a prime coat of zinc chromate primer followed by two coats of aluminum and masonry paint.

2. Concrete, masonry, and plaster: Apply zinc chromate primer, bituminous paint, aluminum and masonry paint, or pressure-sensitive tape to aluminum contact surfaces.

3. Wood or other absorptive materials: Apply two coats of aluminum house paint, and protect aluminum contact surfaces with bituminous paint.

H. Provisions for coating and electrically isolating aluminum and stainless steel, or any other dissimilar metals in contact, when exposed to salt water, water immersion, or burial shall be provided.

I. Welding:

1. Locate welds in assemblies to be anodized so as to conceal visible discoloration in the heat-affected zone.

2. Where weld metal will be exposed after anodizing, select filler alloys to closely match composition of base metal. Follow manufacturer’s recommendations for such filler alloys.

J. Provide pendant fixtures with stem swivel hangers to assure a plumb installation with a minimum 45-degree swing from horizontal in all directions. Where 45-degree movement of fixture is not possible due to field conditions, provide, in addition to above, cross bracing of aircraft cable to restrict movement in direction of potential contact. Tubing shall be not less than 3/16-inch diameter. Motion of swivels or hinged joints shall not cause sharp bends in conductors or damage to insulation. For heavy pendant-mounted fixtures, where support is to be independent of the outlet box, provide stem swivel hangers with fixture studs.

K. Install fixtures to be pole-mounted in accordance with the manufacturer's installation instructions.

3.02 INSTALLATION OF DRIVERS

A. Install drivers, other than those mounted integrally within luminaries, in such a manner that the driver is protected from weather, moisture, and other atmospheric conditions, and in ambient temperatures that will not cause the temperature of the driver housing hot-spot to exceed UL requirements.

B. Voltage drop to lamp, due to remote driver mounting, shall not exceed one percent of the nominal lamp voltage. Provide secondary driver conductors with 600 V insulation. When more than one driver is mounted at one location, the minimum spacing between driver shall be 6 inches in a horizontal direction and 12 inches in a vertical direction. Mount driver components securely in such a manner as to obtain the necessary heat dissipation.

3.03 INSTALLATION OF LIGHT POLES

A. Determine surface and structure load ratings prior to installation of equipment.

B. Install light poles as indicated and in accordance with the manufacturer's installation instructions and recommendations. Light poles shall be grounded as indicated on the Contract Drawings.

3.04 CONCRETE BASES

A. Provide necessary templates and anchor kits before starting work, and coordinate installation of anchors in concrete with the work specified under Division 3 - Concrete.

3.05 INSTALLATION OF EXPOSED PARTS OF FIXTURES

A. Install exposed parts of fixtures after construction, painting, and general cleanup of completed area.

3.06 FIELD QUALITY CONTROL

A. Inspect luminaries, lamps, and associated hardware before and after installation to ensure that they are of the quality and type specified and indicated, and are free of defects and damage.

B. Whenever practicable, test lighting systems at the same time that the distribution panelboard or switchboard is tested.

C. Replace lamps that fail within 90 Days after final acceptance without additional cost to the District.

D. Test light poles for continuity to the grounding system.

E. Inspect lighting fixtures, light poles, and lighting control equipment for labelling.

3.07 TESTING AND COMMISSIONING

A. Contractor shall test and commission installed system per testing and commissioning procedures.

1. Provide checklist of individual lighting fixtures with verification that lighting fixtures are functioning.

2. Provide lighting level measurements per IES or as indicated in Contract Drawings.

END OF SECTION 26 50 00

SECTION 27 13 01

COMMUNICATION CABLES AND RELATED EQUIPMENT

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Single mode and multimode fiber optic cables.

B. Composite cables (OCA combined optical fiber and copper conductors).

C. Telephone cables.

D. Fire telephone and emergency trip system cables.

E. Multiple conductor control cables.

F. SCADA DeviceNet cables.

G. Video coaxial cables.

H. Radio coaxial cables.

I. Slotted radio coaxial cables.

J. Public announcement (PA) cables.

K. Category 6 cables.

L. Category 6A cables and patch cables.

M. Outside plant (OSP) Category 6A cables and patch cables.

N. Related equipment:

1. Optical connectors
2. Fiber entrance cabinets (FEC)
3. Fiber patch panels
4. Category 6/6A patch panels
5. Outlets, hardware, and connections
6. Fiber optic patch cords
7. Pigtail cables
8. Copper splice cases

9. Terminal blocks

10. Test equipment

1.02 RELATED SECTIONS

A. Section 01 33 00, Submittal Procedures

B. Section 01 33 23, Shop Drawings, Product Data and Samples

C. Section 01 43 00, Quality Assurance

D. Section 01 45 00, Quality Control

E. Section 01 78 44, Spare Parts and Maintenance Materials

F. Section 20 50 13, Raceways for Facility Services

G. Section 20 70 13, Common Materials and Methods for Electronic Services

H. Section 20 70 19, Indoor Cabinets, Racks, Frames and Enclosures

I. Section 20 70 23, Electronic Circuits, Wires, and Cables

J. Section 20 70 26, Common Materials and Methods for Electrical Services

K. Section 20 80 00, Systems Integration Testing

L. Section 20 72 25, Factory and Field Testing

M. Section 20 72 15, General Requirements for System Design

N. Section 26 05 24, Low Voltage Wires and Cables

O. Section 26 05 26, Grounding and Bonding for Electrical Systems

P. Section 27 21 00, Unified Optical Network

Q. Section 28 41 29, Closed Circuit Television System

R. Section 27 20 01, Computer and Communication Subsystems

S. Section 33 83 03, Radio Network/Antenna System

T. Section 33 83 06, Radio Network/Bidirectional Radio Amplifier System

U. Drawing K001, Train Control, Communication Cabinets Power and Grounding Requirements

1.03 MEASUREMENT AND PAYMENT

A. The work specified in this Contract Specifications Section will be paid for under the applicable Bid Items based on the locations where work is performed, as identified in the Form – Description of Bid Items, in accordance with Contract Specifications Section 01 20 00, Price and Payment Procedures.

1.04 REFERENCES

A. American National Standards Institute (ANSI):

1. ANSI J-STD-607-A Commercial Building Grounding and Bonding Requirements for Telecommunications, 2002
2. ANSI/TIA/EIA-568 Commercial Building Telecommunications Cabling Standards Set
3. ANSI/TIA/EIA-758 Customer-Owned Outside Plant Telecommunications Cabling Standard

B. American Society for Testing and Materials International (ASTM):

1. ASTM E662 Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials

C. Building Industry Consulting Services International (BICSI):

1. BICSI OSPDRM Outside Plant Design Reference Manual (OSPDRM)
2. BICSI TDMM Telecommunications Distribution Methods Manual, current edition

D. California Code of Regulations (CCR):

1. Title 24, Part 3, California Electrical Code

E. Electronics Industries Association (EIA)/Telecommunications Industry Association (TIA):

1. EIA 359 Standard Colors for Color Identification and Coding
2. TIA-455 General Requirements for Standard Test Procedure for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components
3. TIA-455-3 FOTP-3 Procedure to Measure Temperature Cycling Effects on Optical Fibers, Optical Cable, and Other Passive Fiber Optic Components

4. TIA-455-8	FOTP-8 Measurement of Splice or Connector Loss and Reflectance using an OTDR
5. TIA-455-13	FOTP-13 Visual and Mechanical Inspection of Fiber Optic Components, Devices, and Assemblies
6. TIA-455-25	FOTP-25 Impact Testing of Fiber Optic Cables
7. EIA/TIA-455-34	FOTP-34 Interconnection Device Insertion Loss Test
8. TIA-455-41	FOTP-41 Compressive Loading Resistance of Optical Fiber Cables
9. TIA-455-78	FOTP-78 IEC 60793-1-40 Optical Fibers – Part 1-40: Measurement Methods and Test Procedures – Attenuation
10. TIA-455-88	FOTP-88 Fiber Optic Cable Bend Test
11. TIA-455-91	FOTP-91 Fiber Optic Cable Twist-Bend Test
12. TIA-455-104	FOTP-104 Fiber Optic Cable Cyclic Flexing Test
13. TIA/EIA-455-171	FOTP-171 Attenuation by Substitution Measurement – For Short-Length Multimode Graded-Index and Single-Mode Optical Fiber Cable Assemblies
14. TIA-455-177	FOTP-177 Numerical Aperture Measurement of Graded-Index Optical Fibers
15. TIA-455-204	FOTP-204 Measurement of Bandwidth on Multimode Fiber
16. EIA TIA-4720000	Generic Specification for Fiber Optic Cable
17. EIA 492AAAD	Detail Specification for 850-nm Laser-Optimized, 50-μm Core Diameter/125-μm Cladding Diameter Class 1a Graded-Index Multimode Optical Fibers Suitable for Manufacturing OM4 Cabled Optical Fiber
18. TIA-526-14	Optical Power Loss Measurement of Installed Multi-mode Fiber Cable Plant; Modification of IEC 61280-4-1 edition 2, Fiber-Optic Communications Subsystems Test Procedures – Part 4-1: Installed Cable Plant-Multi-mode Attenuation Measurement
19. TIA-568.0	Generic Telecommunication Cabling for Customer Premises
20. TIA-568.1	Commercial Building Telecommunications Infrastructure Standards

21.	TIA-568.2	Balanced Twisted Pair Telecommunications Cabling and Components Standard
22.	TIA-568.3	Optical Fiber Cabling Components Standard
23.	TIA-598	Optical Fiber Cable Color Coding
24.	TIA-569	Commercial Building Standard for Telecommunications Pathways and Spaces
25.	EIA TIA-606	Administration Standards for the Telecommunications Infrastructure
26.	TIA-607	Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises

F. Insulated Cable Engineers Association, Inc. (ICEA):

1.	ICEA S-84-608	Telecommunications Cable Filled, Polyolefin Insulated, Copper Conductor Technical Requirements

G. Institute of Electrical and Electronics Engineers (IEEE):

1.	IEEE 383	Standard for Qualifying Electric Cables and Splices for Nuclear Facilities
2.	IEEE 730	Standard for Software Quality Assurance Processes
3.	IEEE 802.3	Standard for Ethernet

H. Military Standard:

1.	IAW MIL-STD-188-124-B	Military Standard Grounding, Bonding, and Shielding

I. National Electrical Manufacturers Association (NEMA):

1.	NEMA WC 70	Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy
2.	NEMA WC 71	Nonshielded Cables Rated 2001-5000V for Use in the Distribution of Electric Energy
3.	NEMA WC 74	5-46KV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy

J. International Telecommunication Union (ITU-T):

1.	G.657	Characteristics of A Bending-Loss Insensitive Single-Mode Optical Fibre and Cable

K. National Fire Protection Association (NFPA):

1.	NFPA 70	National Electrical Code 2017
2.	NFPA 262	Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces
3.	NFPA 130	Standard for Fixed Guideway Transit and Passenger Rail Systems
4.	NFPA 780	Standard for Installation of Lightning Protection Systems

L. Rural Electrification Administration (REA):

1.	REA PE-39	Filled Telephone Cables

M. Underwriters Laboratories (UL):

1.	UL 1581	Reference Standard for Electrical Wires, Cables, and Flexible Cords
2.	UL 1666	Standard for Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts
3.	UL 1863	Safety Communications Circuit Accessories

1.05 ABBREVIATIONS

AWG	American Wire Gauge
CD	Chromatic Dispersion
CMP	Communications Plenum Rated
DC	Direct Current
DMP	Designated Matching Products
DS	Digital Signal
ETS	Emergency Trip System
FEC	Fiber Entrance Cabinet
FRPE	Flame-retardant Polyethylene
GRP	Glass Reinforced Plastic
IAW	In Agreement With

IP	Internet Protocol
IPP	Internet Protocol Precedence
LAN	Local Area Network
LC	Lucent Connector
LSZH	Low Smoke Zero Halogen
MM	Multimode
NMS	Network Management System
OADM	Optical Add-Drop Multiplexer
OCC	Operations Control Center
OFNP	Optical Fiber Non-Conductive Plenum
OM4	Optical Multimode 4
ONS	Optical Network System
OPL	Optical Power Loss
ORL	Optical Return Loss
OSA	Optical Spectrum Analyzer
OTDR	Optical Time Domain Reflectometer
OTN	Optical Transport Network
PMD	Polarization Mode Dispersion
PTC	Project Test Center
QoS	Quality of Service
SC	Subscriber Connector
SCADA	Supervisory Control and Data Acquisition
SDH	Synchronous Digital Hierarchy
SFP	Small Form-Factor Pluggable
SM	Single mode
TCH	Train Control House

TCR	Train Control Room
TDM	Time Division Multiplexing
ToS	Type of Service
UAN	Unified Administration Network
UON	Unified Optical Network
UPC	Ultra Physical Contact
UTP	Unshielded Twisted Pair
UV	Ultraviolet
VLAN	Virtual Local Area Network
VSS	Video Surveillance System
WDM	Wave Division Multiplexing
XFP	Small Form-Factor Pluggable (10 Gigabit)

1.06 SUBMITTALS

A. General: Refer to Contract Specifications Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Submittal Requirements: Before installation of wires and cables, submit complete product data sheets for each type and size of wire and cable required for the project. Provide optical loss calculations for each span of the fiber optic network and indicate total anticipated optical loss in dB between OADM nodes.

C. Factory and Field Test Plans and Reports: Submit factory and field test plans and reports in accordance with Contract Specifications Section 20 72 25, Factory and Field Testing and Contract Specifications Section 20 80 00, Systems Integration Testing. Completed field test reports for all fiber and copper cables shall be submitted to the District for approval.

1.07 QUALITY ASSURANCE AND QUALITY CONTROL

A. Refer to Contract Specifications Section 01 43 00, Quality Assurance, and Contract Specifications Section 01 45 00, Quality Control, for hardware quality assurance requirements and IEEE 730 for software quality assurance requirements.

B. Products shall be manufactured by firms regularly engaged in manufacturing products described in this Section.

C. Field testing shall be performed by persons having five or more years of relevant testing experience.

1.08 DELIVERY, STORAGE, AND HANDLING

1. Provide markings on wire and cable in accordance with applicable NEMA and California Electrical Code requirements. Each item shall be labeled with UL listing approval.

2. Ship each unit securely wrapped, packaged, and labeled for safe handling in shipment and to avoid damage.

3. Store wire and cable in a secure and dry storage facility.

4. If fiber optic cable is packaged for shipment, the reels shall be non-returnable wooden reels with a maximum reel diameter of 78 inches. The top and bottom ends of the cable shall be available for testing. Both ends of each cable shall be sealed to prevent the ingress of moisture.

PART 2 – PRODUCTS

2.01 SINGLE MODE FIBER OPTIC CABLE

A. General

1. Outside plant inter-facility cables shall be non-armored, gel-free, water blocking tape, single mode.

2. Single mode cable shall meet the requirements of the National Electrical Code® (NEC)® Section 770 and the Low Smoke Zero Halogen – Applicable Flame-Smoke Test: UL 1685. Cables shall be manufactured in accordance with TIA-455-13, TIA-455-25, TIA-455-41, TIA-455-78, TIA-455-88, TIA-455-91, TIA-EIA 455-104, TIA/EIA-455-171, TIA-455-177, and TIA-455-204.

3. Finished cables shall conform to the applicable performance requirements of the Insulated Cable Engineers Association, Inc. (ICEA) Standard for Indoor-Outdoor Optical Fiber Cable (ICEA S-104-696).

4. Fiber optic cable assemblies, including jacketing and fibers shall be certified by the manufacturer to have a minimum life of 25 years.

5. Jacket printing: Each shipping length of cable shall be permanently identified by printing on the outer surface of the jacket, at intervals of five feet or less. Information shall include count of fibers, fiber type and size, cumulative footage markers, manufacturer’s designation, plant name (if applicable), and manufacturer’s name.

6. Single mode fiber optic cables shall have a bend performance that meets ITU-T G.657.

7. Single mode terminations shall be anaerobic, or fusion spliced for backbone cabling.

8. Count of optical fibers in each cable run, including fibers reserved for future use and for spares, shall be as indicated.

B. Fiber Specifications

1. Type: Single-mode, loose tube, gel-free, non-armored, Category OS2 rated.

2. Operating wavelength: 1310/1550 nm

3. Attenuation at 1310 nm: 0.35 dB/km, maximum

4. Attenuation at 1383 nm: 0.35 dB/km, maximum

5. Attenuation at 1550 nm: 0.22 dB/km, maximum

6. Polarization Mode Dispersion Link Value: 0.1 maximum.

C. Cable Construction

1. Optical fibers shall be placed inside a loose buffer tube. The nominal outer diameter of the buffer tube shall be 3.0 mm.

2. Each buffer tube shall contain up to 12 fibers. The fibers shall not adhere to the inside of the buffer tube. Buffer tubes shall be resistant to kinking.

3. Each fiber shall be distinguishable by means of color coding in accordance with TIA/EIA-598, Optical Fiber Cable Color Coding. The fibers shall be colored with ultraviolet (UV) curable inks. Buffer tube colored stripes shall be inlaid in the tube by means of co-extrusion when required. The nominal stripe width shall be 1 mm.

4. In buffer tubes containing multiple fibers, the colors shall be stable across the specified storage and operating temperature range and not subject to fading or smearing onto each other. Colors shall not cause fibers to stick together.

5. Fillers may be included in the cable core to lend symmetry to the cable cross-section where needed. Fillers shall be placed so that they do not interrupt the consecutive positioning of the buffer tubes.

6. The central member shall consist of a dielectric, glass reinforced plastic (GRP) rod. The purpose of the central member is to prevent buckling of the cable. The GRP rod shall be over coated with a thermoplastic, when required, to achieve dimensional sizing to accommodate buffer tubes/fillers.

7. Buffer tubes shall be stranded around the dielectric central member using the reverse oscillation, or “S-Z,” stranding process. Water blocking yarn(s) shall be applied longitudinally along the central member during stranding.

8. Two polyester yarn binders shall be applied contra helically and with sufficient tension to secure each buffer tube layer to the dielectric central member without crushing the buffer tubes. The binders shall be non-hygroscopic, non-wicking and dielectric with low shrinkage.

9. Flame-retardant tape may be applied to provide resistance to flame propagation. A water blocking tape shall be applied longitudinally around the outside of the flame-retardant tape.

10. The tensile strength shall be provided by the central member, and additional dielectric yarns as required. The dielectric yarns shall be helically stranded evenly around the cable core.

11. The jacket material shall be a flame-retardant, low-smoke, zero-halogen (LSZH) insulating compound that is ultraviolet (UV) resistant. Cables shall contain at least one ripcord under the sheath for easy sheath removal.

12. The jacket shall be continuous, free from pinholes, splits, blisters, or other imperfections. The jacket shall have a consistent, uniform thickness; jackets extruded under high pressure are not acceptable. The jacket shall be smooth, as is consistent with the best commercial practice. The jacket shall provide the cable with a tough, flexible, protective coating, able to withstand the stresses expected in normal installation and service.

2.02 MULTIMODE FIBER OPTIC CABLE

A. General

1. Inside plant, intra-facility cables shall be 50 microns multimode.

2. Cables shall be manufactured in accordance with TIA-455-13, TIA-455-25, TIA-455-41, TIA-455-177, TIA-455-78, TIA 455-88, TIA 455-91, TIA 455-104, and TIA/EIA 455-171.

3. Finished cables shall conform to the applicable performance requirements of the Insulated Cable Engineers Association, Inc. (ICEA) Standard for Indoor-Outdoor Optical Fiber Cable (ICEA S-104-696).

4. Fiber optic cable assemblies, including jacketing and fibers shall be certified by the manufacturer to have a minimum life of 25 years.

5. Each shipping length of cable shall be permanently identified by printing on the outer surface of the jacket, at intervals of five feet or less. Information shall include count of fibers, fiber type and size, cumulative footage markers, manufacturer’s designation, plant name (if applicable), and manufacturer’s name or UL file number.

6. Individual fibers shall be color coded for identification in accordance with EIA TIA-598-A.

7. Count of optical fibers in each cable run, including fibers reserved for future use and for spares, shall be as indicated.

8. Multimode fiber optic cables shall have an OM4 multimode classification and be 550 MHz bend optimized, compliant to the IEC 60793-2-10, Type A1a.3 Fiber, and TIA/EIA-492AAAD standard.

9. Multimode fiber optic cables shall have a bend performance that meets ITU-T G.657.B.

10. Multimode fiber terminations shall be anaerobic or fusion spliced for backbone cabling.

B. Fiber Specifications

1. Type: Tight buffered, graded index multimode cables without armor and with an outer jacket rated for plenum or non-plenum duty as applicable.

2. Operating Wavelength and Bandwidth: 160 MHz·km at 850 nm and 500 MHz·km at 1300 nm.

3. Attenuation at 850 nm: 3.75 dB/km, maximum.

4. Attenuation at 1300 nm: 1.00 dB/km, maximum.

5. Core diameter: 50 μm plus or minus 3.0 μm optimized for 550 meters.

6. Cladding diameter: 125.0 μm plus or minus 2.0 μm.

7. Each tube and buffered fiber shall be color-coded to provide unique and permanently visible identification, in accordance with EIA 359-A.

8. Optical Performance: The attenuation shall be measured in accordance with EIA TIA-455-78. The bandwidth shall be measured in accordance with EIA TIA-455-30 or EIA TIA-455-204.

C. Cable Construction

1. Fibers shall be tight buffered to 900 μm diameter, using a tough elastomeric buffer material.

2. Buffered fibers to be stranded together with dielectric strength members.

3. Inner cable jacket to be pressure-extruded onto cabled fibers and strength members in the core assembly. This jacket material shall be of zero-halogen flame-retardant composition.

4. The jacket material shall be a flame-retardant, LSZH insulating compound that is UV resistant. The outer jacket shall be extruded over the shield in a tight-fitting assembly.

5. A 0.006-inch thick (minimum) corrugated electrolytic chrome coated steel tape, plastic coated on both sides, shall be tightly wrapped, around the inner jacket.

6. A ripcord (or two ripcords) of compatible material shall be built into the cable assembly, to facilitate removal of the wrap and jackets during installation.

2.03 COMPOSITE CABLE

A. Provide composite cables with combined optical fiber and copper conductors. Cables shall be composed of a 2-strand tight buffered fiber and 2 – No. 12 AWG copper conductors, one port assembly with associated connectors. Cables shall be a Designated Matching Product (DMP).

2.04 TELEPHONE CABLES

A. Non-IP telephone requirements:

1. Indoor cables shall be a 25-pair cable, unshielded twisted pair (UTP), communications plenum rated (CMP), 24 AWG, solid; or Category 6 cable, UTP, CMP, grey-jacketed color, from the punch block to the patch panel or from the patch panel to the phone.

2. Outdoor cables shall be a 25-pair cable, 24 AWG, solid, direct burial cable under REA PE-39 specification.

B. Provide Category 6 telephone cables with a minimum of four pairs for inside plant line circuits. Inter-cabinet tie cables shall be UTP, 25, 50 or 100 pair cables as required to meet the active pair count as shown on the Contract Drawings including 50 percent spare pairs. Plenum cable shall be used where required by code(s). Use blue-jacketed cable for data and data/voice cables and green-jacketed cable for voice-only cables.

C. Telephone cables shall be certified by the manufacturer to have a minimum life of 40 years.

D. Category 6 or 6A cables shall be LSZH compliant in accordance with NFPA 70.

2.05 FIRE TELEPHONE AND EMERGENCY TRIP SYSTEM CABLES

A. Fire telephone and emergency trip system cables shall be six pair, 19 AWG solid, soft-annealed, insulated copper conductors with an overall shield. Cables shall meet the requirements of REA Specification PE-39 – Filled Telephone Cables. Fire telephone and emergency trip system cables shall be certified by the manufacturer to have a minimum life of 40 years.

2.06 MULTIPLE CONDUCTOR CONTROL CABLE

A. Provide multiple conductor cable conforming to NEMA WC 70, NEMA WC 71, and NEMA WC 74, approved for use in cable tray, with the following additional requirements:

1. Number of insulated conductors: As indicated in drawings.

2. Insulation: Rated for 600V.

3. Overall covering: Cable shall be jacketed over the insulation.

4. Multiple conductors for control wire shall be a minimum of No. 14 AWG stranded copper.

B. Multi-conductor cable shall be made by assembling individual or twisted pairs of insulated conductors into a tight cylindrical form using fillers that are compatible with other materials in the cable. The jacket used shall fit tightly to form a firm assembly.

C. Multi-conductor cable shall be certified by the manufacturer to have a minimum life of 40 years.

D. Cables shall be LSZH compliant in accordance with NFPA-70.

2.07 SCADA DEVICENET CABLE

A. SCADA DeviceNet cable shall be a DMP.

2.08 VIDEO COAXIAL CABLE

A. Provide coaxial cables for analog video signal transmission:

1. 75 ohm characteristic impedance.

2. Double braided copper shield.

3. No. 20 AWG solid copper center conductor.

2.09 RADIO COAXIAL CABLE

A. Provide coaxial cables for radio signal transmission. Coaxial cables shall be size 1/4 inch minimum, jacketed, corrugated, low density foam-filled for trunked radio applications. The minimum design requirements and general characteristics are as follows:

1. 50 ohm characteristic impedance.

2. VSWR shall be 1.2: maximum at center frequency.

3. Minimum bending radius shall be 10 inches.

4. Attenuation shall not exceed 1.8 dB, referenced to MHz.

5. Outer conductor shall be solid copper.

6. Inner conductor shall be copper.

7. The cable shall be permanently identified.

8. Connectors shall be EIA type N jack (female) on both ends.

9. Grounding kits shall be provided to ground all coaxial cables to the tower top, tower bottom, and at the building entrance.

10. Snap-in hanger kits shall be provided to mount coaxial cable directly into holes in the tower support members.

2.10 SLOTTED RADIO COAXIAL CABLE

A. The minimal design requirements and general characteristics of the slotted coaxial cables are as follows:

1. The slotted coaxial cables shall pass the UL 854 and 1581 flame tests (similar to IEEE 383, NES 711/713, and IEC 332-3), UL listed under Article 820 of the National Electrical Code, and all code requirements must be approved by the fire inspector.

2. The slotted coaxial cables shall be jacketed, corrugated foam-filled cables suitable for mounting to a metallic (galvanized steel) messenger wire or hangers.

3. Cable jacket shall offer fire-retardant, hydro-carbon protection, halogen-free performance, low-level smoke and toxic fume emissions. The jacket shall be vertical tested and approved by Underwriters Laboratories.

4. Coupling loss measured at 20 feet shall not exceed the following:

    a. Coupling Loss (dB) @ Frequency Band (MHz).

        1) 82 @ 800
        2) 82 @ 900
        3) 73 @ 1800
        4) 72 @ 1900
        5) 71 @ 2200

5. Characteristics impedance shall be 50 ohms.

6. Typical VSWR shall be less than 1.3:1, referenced to 30, 150, 450 and 900MHz.

7. Minimum bending radius shall be 10 x diameter.

8. Attenuation measured at free space shall be less than 1.0 dB per 100 feet, referenced to 900 MHz.

9. Inner and outer conductors shall be copper.

10. The cable shall be permanently identified.

11. Slotted coaxial cables shall be factory assembled, tested and furnished in continuous reel lengths of 2300 feet maximum with factory installed EIA type N female connectors on both ends.

12. The outer conductor shall be two layers of mica insulated barrier tape wrapped around the conductor to prevent dielectric material from leaking through the slots under fire conditions.

13. The cable shall have a flooding compound between the jacket and outer conductor barrier tape to prevent entry of water.

2.11 PUBLIC ANNOUNCEMENT (PA) CABLES

A. Provide PA 70V cable for PA speaker and amplifier hookup: No. 16 AWG cable shall cover overall length within station.

1. The PA cable shall be Belden 1307A, West Penn AQC225, No. 16 AWG stranded, grey color, indoor/outdoor, UL listed.

2.12 CATEGORY 6 CABLE

A. Category 6 cable and patch cables shall meet the TIA/EIA 568C standard and conform to the following requirements:

1. Unshielded cables shall only be utilized in non-wayside facilities. Unshielded cables shall be plenum rated with four balanced, unshielded twisted pairs (UTP). Conductors shall be No. 24 AWG solid copper. Cable insulation jackets shall be color coded for the service type: blue for data, white for voice, and green for video applications.

2. Shielded cables shall be used in wayside facilities. Shielded cables shall be plenum rated with an overall foil tape shield and four balanced, unshielded twisted pairs (F/UTP). Conductors shall be No. 24 AWG solid copper. The shield shall be an aluminum foil tape enclosing a No. 24 AWG tinned copper drain wire. Cable insulation jackets shall be color coded for the service type: blue for data, white for voice, and green for video applications.

3. Cable jackets shall be legibly marked with the following information:

   a. Manufacturer’s name

   b. Copper conductor gauge

   c. Pair count

d. UL or CSA listing

e. Manufacturer's trademark

f. Category rating, including UTP, F/UTP or ScTP (screened twisted pair)

g. Sequential foot markings, in one- or two-foot increments

4. Unshielded Category 6 patch cables shall be rated for 250 MHz or better and shall be composed of four, No. 24 AWG stranded copper conductor pairs with 50-micron, gold plated RJ-45 male to male connectors and a plenum jacket.

   Shielded Category 6 patch cables shall be rated for 250 MHz or better and shall be composed of four, No. 24 AWG stranded copper conductor pairs with shielded 50-micron, gold plated RJ-45 male to male connectors, an overall shield with aluminum foil tape enclosing a No. 24 AWG tinned copper drain wire, and a plenum jacket.

B. General

1. Patch cable length shall meet eight feet unless approved by the Engineer. Patch cable exceeding eight feet shall be run between individual Category 6A patch panels with modular jacks.

2. Outside plant cable (OSP) rated cable shall be required for below-ground conduit installations.

3. Indoor rated cable is permitted for above ground conduit installations where cable is not exposed to the outdoor conditions. In areas where conduit installation is not environmentally controlled or exposed to out-door conditions, provide grounding in accordance with NEC.

4. Cable installations not in conduit shall be terminated on primary protector blocks equipped with 5-pin solid state or gas protector modules. The protector blocks shall be bonded to the lightning protection ground with a No. 6 AWG or larger ground wire. Terminals and hardware shall be UL-listed, made of a flame-retardant construction, and equipped with a built-in splice chamber; 5-pin gas protector modules; locking cover; and output on 110 blocks, or RJ connectors. The protector block shall be placed as close to the lightning protection ground as possible.

5. Patch cords shall be factory made, and not spliced and terminated on-site. Patch cords shall have strain-relief RJ-45 non-keyed connectors. Patch cords shall terminate positions of the connector.

C. Category 6A cable and patch cables shall meet with the TIA/EIA 568C standard and conform to the following requirements:

1. Shielded cables shall be used in wayside facilities and for power over Ethernet (PoE/PoE+) connectivity requirements. Shielded cables shall be CMP-rated, plenum-rated with an overall foil tape shield and four-balanced, and unshielded twisted pairs (F/UTP). Conductors shall be No. 23 AWG to No. 24 AWG solid copper. The shield shall be an aluminum foil tape enclosing a No. 23 AWG to No.26 AWG tinned copper drain wire. Cable shields and drain wire shall be installed to connect to the building signal ground in accordance with ANSI-J-STD-607-A.

2. Cable jackets shall be legibly marked with the following information:

   a. Manufacturer’s name

   b. Copper conductor gauge

   c. Pair count

   d. UL or CSA listing

   e. Manufacturer’s trademark

   f. Category rating, including UTP or F/UTP

   g. Sequential foot markings, in one- or two-foot increments

3. Shielded Category 6A patch cables shall be CMP-rated, with a plenum-rated jacket rated for 500 MHz or better and shall be composed of four, No. 23 AWG to No. 24 AWG stranded copper conductors with shielded 50-micron, gold plated RJ-45 male to male connectors, an overall shield with aluminum foil tape enclosing a No. 23 AWG to No. 26 AWG tinned copper drain wire.

2.13 OSP CATEGORY 6A CABLE AND PATCH CABLES

A. Cable Length

1. The maximum allowable horizontal cable distance is 90 m of installed cabling, with 100 m of maximum total length including patch cords. Patch cord shall not be longer than 10 feet, and horizontal cable length shall not exceed 290 feet.

B. Cable Entrance Grounding

1. Metallic shields and strength members for OSP cable entering a building shall be connected to the lightning protection ground system. Lightning protection shall meet IAW MIL-STD-188-124-B and NFPA 780.

C. Building Point of Entrance

1. The point of entrance shall be located where “the wire or cable emerges from an external wall, from a concrete floor-slab, or from a rigid metal conduit or an IMC grounded to an electrode IAW 800.400-B.” The Telecommunications Entrance Facility (TEF) is the space housing the point of entrance of the telecommunications service.

D. Copper Cable Entrance

1. OSP copper cable shield, armor, and metallic strength members shall be bonded to the lightning protection ground as close to the building point of entrance as possible with a No. 6 AWG or larger ground wire. A non-bonded splice case shall be used for the transition from OSP-rated cable to interior-rated cable. The splice case shall not be carried through the bonding conductor. If the OSP copper cable is extended past 50 feet (15 m), the metallic strength member shall be bonded to the lightning protection ground as close to the conduit egress point as possible with a No. 6 AWG or larger copper ground wire. The fault protector and associated equipment shall be housed in a junction box with din-rail mounted industrial style patch panel modules to facilitate an indoor and OSP cable demarcation.

E. Copper Protector Block

1. OSP copper cables shall be terminated on primary protector blocks equipped with 5-pin solid state or gas protector modules. The protector blocks shall be bonded to the lightning protection ground with a No. 6 AWG or larger copper ground wire. Terminals and hardware shall be UL-listed, made of a flame-retardant construction, and equipped with a built-in splice chamber; 5-pin gas protector modules; locking cover; and output on 110 blocks, or RJ connectors. The protector block shall be placed as close to the lightning protection ground as possible.

F. CCTV Remote Junction Box

1. CCTV cameras shall connect to OSP cable via remote junction boxes collocated with camera mounting location. Provide junction box equipment as indicated.

2.14 OPTICAL CONNECTORS

A. Patch Panel Connectors: LC ultra-polished connector (UPC) with 126 µm (single mode) or aqua 127 µm (multimode) ceramic zirconia alignment ferrules shall be used for fiber patch panels. Connector insertion loss shall be nominally 0.3 dB and less than 0.5 db. LC connectors shall be field installable. Dust caps shall be provided for sleeves.

B. Equipment Connectors

1. Fiber optic connectors shall match and be compatible with equipment terminations. Connector insertion loss shall be nominally 0.3 dB and less than 0.5 dB. Connectors shall be field installable. Dust caps shall be provided for all sleeves.

    a. Equipment connector

        1) LC (Lucent Connector) UPC.

2. Multimode connectors shall be an aqua multimode LC connector pair with a duplex clip, a 127 µm ceramic zirconia ferrule, supplied with a white 900 µm for buffered fiber and a 1.6 mm boot with white and yellow shrink sleeves for patch cables.

3. Single mode connectors shall be a single mode LC connector pair with a duplex clip, a 126 µm ceramic zirconia ferrule, supplied with a white 900 µm for buffered fiber and a 1.6 mm boot with white and yellow shrink sleeves for patch cables.

2.15 FIBER ENTRANCE CABINETS (FEC)

A. Wall-mounted fiber entrance cabinets (FECs) shall be provided in the TCH and the TCR.

B. FECs shall be Designated Matching Products (DMP) and equipped with the accessories specified below:

Commercial FEC

Quantity	Description
1	FEC standard 36 drawer (864 fiber) cabinet
36	Fiber splice trays (24 fiber)
96	Heat shrink protector sleeves
8	FEC cable clamp OD 0.8"
1	Unistrut bracket

BART FEC

Quantity	Description
1	FEC standard 12 drawer (288 fiber) cabinet
12	Fiber splice trays (24 fiber)
36	Heat shrink protector sleeves
2	FEC cable clamp OD 0.8"
1	Unistrut bracket

2.16 FIBER PATCH PANELS

A. Fiber patch panels shall be a complete system of components furnished by a single manufacturer, and shall provide termination, splice storage, routing, radius limiting, cable fastening, storage, and cross-connection. Fiber patch panels shall be Designated Match Products (DMP) with specified accessories. Patch panels shall employ wall-mountable connector housings equipped as follows:

1. Sized to accommodate 48 fibers.

2. Three multi-mode connector panels accommodating 12 fibers with LC connectors.

3. One single-mode connector panel accommodating six fibers with LC connectors.

4. Four splice trays with splice protectors.

5. One splice tray holder.

2.17 CATEGORY 6/6A PATCH PANELS

A. Category 6/6A Patch Panel Design Requirements:

1. Patch panels shall employ a modular keystone design that utilizes both unshielded Category 6 jacks and shielded Category 6A jacks installed into each panel position. Panels shall have provisions for connection of grounding jumpers from each installed shielded jack to support Category 6A shielded keystone jacks and patch panel to telecommunications grounding bus (TGB).

2. Unshielded Category 6 jacks and shielded Category 6A jacks supplied with the panel shall be modular in design and meet the TIA/EIA-568-C.2 Balanced Twisted – Pair Telecommunications Cabling and Component Standard. Unshielded Category 6 jacks and shielded category 6 jacks shall also be available separately with detailed installation instructions.

3. Panel ports shall have a rectangular, industry standard keystone opening (0.760 inches by 0.580 inches) with a permanent port identifier number under each opening.

4. Panels shall include a compatible cable management of patch cords in the front and horizontal cable management in the rear.

5. Panels with installed jacks shall be backward compatible with existing keystone modular jack systems for fit, form, and function.

6. Panels shall be a Designated Matching Product (DMP).

B. Category 6/6A Patch Panel Performance Requirements:

1. Transmission parameters shall be verified by a UL or ETL testing organization. Transmission testing shall be to 250 MHz for Category 6 and 500 MHz for Category 6A.

2. Panels with unshielded jacks shall meet transmission requirements specified in ANSI/TIA/EIA-568-C (specification limit is 250 MHz).

3. The manufacturer shall provide compliance certificates from a third-party testing organization upon request.

4. Panels shall be UL listed 1863 and CSA certified.

5. Panels shall exceed IEEE 802.3 DTE power specification to four times the rated current limits with no degradation of performance or materials.

6. Panels shall be third party verified to Gigabit Ethernet performance according to IEEE 802.3Z (current draft).

7. Panels shall meet or exceed the four-connector channel performance requirements of ANSI/TIA/EIA-568-C.2 standard. Panels shall support unshielded Category 6 and shielded Category 6A keystone jacks from the same manufacturer.

8. Keystone Jacks: The four-connector channel test configuration shall utilize unshielded Category 6 jacks, patch panels, and patch cords, from the same manufacturer, with qualified unshielded twisted pair (UTP) Category 6 cable.

9. Shielded Keystone Jacks: The four-connector channel test configuration shall utilize shielded Category 6A jacks, patch panels, and patch cords, from the same manufacturer, with qualified shielded (F/UTP) Category 6A cable.

2.18 OUTLETS, HARDWARE, AND CONNECTIONS

A. Work Area Outlets (WAOs): WAOs shall be Category 6/6A keystone jacks with universal wiring (TIA568A/B) mounted in single or dual port faceplates as required when within TIA568C.1 length specifications. Category 6/6A WAOs exceeding TIA568C.1 length specifications can use fiber cable terminated to District approved flush-mounted wall boxes or fiber style keystone jacks with 2 or 3 duplex port face plates as required.

B. Category 6/6A Keystone Jack color:

1. Wayside Facilities

a. Red - Analog Telephone

b. Yellow - Digital Telephone

c. Purple - IP Telephone (voice only)

d. Green - Async, T1 Connection

e. White - Administrative network

f. Orange - Network Management Systems (NMS) network

g. Black - Security network

h. Blue - BARTnet network

i. Grey - Unassigned

j. Beige - Unassigned

2. Central Facilities: Shall be coordinated with the District

C. Fiber Keystone Jack Color:

1. Shall be coordinated with the District

D. Destination Sign Unit (DSU) Connector Modules: Connector modules for DSU outlets shall be Designated Matching Product. Sign hangers shall be constructed of ASTM A500 Grade B structural steel tubing.

E. Automatic Fare Collection (AFC) Equipment Fiber Interface Box: Telecommunication outlets for AFC equipment fiber cable connection shall be Designated Matching Product. Three dual ST to ST connector sleeve insert modules shall be Designated Matching Products, and be furnished for each AFC equipment Fiber Interface Box.

F. Category 6/6A keystone jacks shall be Designated Matching Products.

2.19 FIBER OPTIC PATCH CORDS

A. Patch cords shall be cable assemblies consisting of optical fiber cable with bend performance that meets ITU-T G.657.B equipped with compatible connectors. Patch cords shall be complete assemblies from manufacturer’s standard product lines. Length shall be as required. Patch cords shall meet the following requirements:

1. Fiber optic patch cords shall be two-fiber zip cord type with a 1.6 mm OD.

2. Cable construction shall allow a small bend radius for installation in space constrained areas. The cable shall contain a dielectric strength member and a protective outer jacket. The fiber core size shall be identified on the outer jacket.

3. Fibers shall be terminated at each end with UPC connectors as specified herein.

4. Patch cords shall have a bend performance that meets ITU-T G.657.

5. Patch cords for single-mode fiber shall be colored yellow.

6. Patch cords for multi-mode shall be colored aqua and OM4 rated unless approved otherwise.

7. Patch cords shall be complete factory fabricated assemblies from manufacturer standard product line. Lengths shall meet manufacturer's standard lengths. Field fabricated patch cords shall not be used.

2.20 PIGTAIL CABLES

A. Cables used for connections to equipment shall be flexible fiber pigtail cables having the same physical and operational characteristics as the parent cable. The cable jacket shall be flame retardant PVC or FCP, which complies with NFPA 70 for OFNP applications. Maximum dB loss for pigtail cables shall be 3.5 dB/km at 850 nm, and 1.0 dB/km at 1300 nm.

2.21 COPPER SPLICE CASES

A. Cases for splicing copper cables shall be of the type capable of being re-opened without disturbing splices, and of being reclosed. Cases shall have devices for centering cable to allow filling compound to cover conductors. Hardware shall be of stainless steel. Cases shall be braced to prevent cracking.

1. Filling Compound: Compound for filling splice cases shall be a polyurethane telephone material that is transparent after curing. The compound shall adhere to conductors and splices but shall be capable of being easily pulled away in a mass from conductors and splices. Compound shall be non-corrosive to conductors and splicing devices and shall not be toxic.

2. Splice Connectors: Connectors shall be sized for the specific conductors to be spliced or tapped. The connector material shall be compatible with the conductor. The tools used for application shall have a positive action that prevents over- or under-crimping.

2.22 TERMINAL BLOCKS

A. Terminal blocks shall be DIN-rail mounted, single, or two level as required by the application, and meet the following requirements:

1. Wire gauge range: No. 28 AWG to No. 12 AWG.

2. Current rating: 25 amps.

3. Voltage rating: 600 V.

4. Terminal width: 5 or 6 mm.

5. DIN rail: 35 mm.

B. Terminal blocks shall be labeled.

2.23 TEST EQUIPMENT

A. Test equipment shall be turned over to the District in good condition upon completion of testing. A test report including data sheets shall be generated by tester and submitted to the District for approval.

B. Multifunction loss testers shall perform the following instrument functions:

1. Optical power loss (OPL) meter.
2. Power meter.
3. Optical return loss (ORL) meter.
4. Visual fault locator.
5. Multimode and single mode light sources.
6. Digital talk set.
7. Fiber length tester.
8. Video fiber inspection probe.

C. The multifunction loss tester shall be an EXFO FOT-930 MaxTester or equal. The Contractor may use the testers for ORL and optical power loss testing.

D. The optical spectrum analyzer (OSA) shall be optimized for 100 GHz spacing and DWDM network testing. The OSA shall be EXFO model FTB-5230 or equal.

E. The copper and fiber cable analyzer shall provide certification testing meeting EIA/TIA standards. The cable analyzer (copper and fiber) shall be model FLUKE DTX-1800-MSO or equal.

F. Surface Inspection interferometer testing for field fiber connector termination. The surface Inspection interferometer shall be model DAISI Digital Automated Interferometer or equal.

2.24 FACTORY TESTS

A. Refer to Contract Specifications Section 20 72 25, Factory and Field Testing.

B. Cable Tests: Test single mode and multimode fiber optic cables in accordance with EIA RS-455.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Coordinate installation of wires and cables with the requirements of Contract Specifications Section 20 70 26, Common Materials and Methods for Electrical Systems, and Section 20 50 13, Raceways for Facility Services.

B. Provide wiring complete as indicated. Provide ample slack for field terminated wires and preformed cables with connections, including wires for motor loops, service connections, and extensions. In outlet or junction boxes provided for installation of equipment by others, tape ends of wires and install blank covers.

C. Do not bend cables during installation, either permanently or temporarily, to radii less than 12 times the outer diameters, except where conditions make the specified radius impractical and shorter radii are permitted by the California Electrical Code, NEMA WC 70, NEMA WC 71, and NEMA WC 74.

D. Bundle cable and conductors neatly and securely with nylon straps located in branch circuit panelboards, equipment cabinets, and control panels. Use nylon bundling straps. Bundle power cables separately from control cables.

E. For wire pulling, comply with the following requirements:

1. Do not pull wires into conduit until conduits and outlets have been thoroughly cleaned and swabbed. Do not use a block and tackle or other mechanical means for pulling conductors smaller than No. 2 AWG in raceways.

2. Use lubricant and installation procedure as recommended by the cable manufacturer.

3. Pulling tension shall not exceed manufacturer’s recommendations. For conduit runs with three bends, provide the Engineer with cable pulling calculations prior to making the pull.

4. Provide masking or other means to prevent obliteration of cable identifications when solid color coating or colored tracers are used.

5. Multiple cables to be installed in a single conduit shall be pulled together.

F. Power and Control Cable Installation in Manholes and Pull Boxes: Route cables along the manhole or hand-hole walls providing the longest possible slack. Form cables closely parallel to the walls so that they do not interfere with duct entrances, supported on brackets and cable insulators spaced at a maximum of four feet. In existing manholes and hand-holes where new ducts are to be terminated or where new cables are to be installed, modify the existing locations of cables, cable supports, and grounding as required providing a properly arranged and supported installation.

G. Wayside Copper Cable: Wayside copper cable shall be homerun from the device such as the telephone in a BLS to the protector blocks in the associated wayside facility. Wayside copper cable splicing is not allowed.

H. Install fiber optic cables as follows:

1. Install horizontal and inter-facility fiber optic cables in conduit. Provide unused conduits with lubricated pull tape or line.

2. Conduit runs for fiber optic cable shall only use pull boxes. Condulets shall not be used.

3. Install each communication cable, including traction power cables, between wayside facilities in the communications section of the system-wide raceway.

4. Install each train control cable between TCRs or TCHs in the train control section of the systemwide raceway.

5. Install lateral cables between the systemwide raceway and wayside facilities in separate conduits.

6. Spare fibers shall be secured and supported neatly with velcro.

7. Terminate backbone and horizontal fiber optic cable to maintain manufacturer-recommended bending radii, pulling tension, and cable support requirements. Cables and equipment shall be securely and neatly installed. Inside routing shall be installed parallel and perpendicular to existing structural lines and members. Plastic or metal cable ties shall not be used; only velcro or millipede ties are permitted.

8. Service loops shall be provided in communication manholes, above fiber entrance cabinets, and related enclosures. Fiber optic cable runs with a portion of the run exterior to a building shall have a minimum service loop length of 50 feet on each end. Fiber optic cables installed completely inside of a building shall have a minimum service loop length of 12 feet on each end.

I. Fiber optic cable pulling shall comply with the following:

1. Pull on the cable strength members only. Do not pull on the jacket unless it is specifically approved by the cable manufacturer and an approved cable grip is used.

2. Do not exceed the maximum pulling load rating. On long runs, use proper lubricants and make sure they are compatible with the cable jacket. If possible, use an automated puller with tension control or at least a breakaway pulling eye.

3. Do not exceed the cable bend radius.

4. Do not twist the cable. Roll the cable off the spool instead of spinning it off the spool end. When laying cable out for a long pull, use a “figure eight” on the ground or use a swivel pulling eye to prevent twisting forces on the cable.

5. Verify that the cable is long enough for the run.

J. Shields of cables shall be grounded at the equipment room end per Specification Section 26 05 26, Grounding and Bonding for Electrical Systems, and Standard Drawing K001.

3.02 CABLE IDENTIFICATION

A. Provide nonmetallic fiberboard or plastic identification tags or pressure sensitive labels designed for fastening to cables, feeders, and power circuits in vaults, pull boxes, manholes, and switchboard rooms, and at terminations of cable or wire.

B. Stamp or print tags or labels to correspond with markings on the Contract Drawings, or mark so that feeder or cable may be readily identified.

C. If suspended type identification tags are provided, attach the tags to slip-free plastic cable lacing units or to nylon bundling straps.

3.03 CABLE LABELING

A. Provide identification tags or labels for each cable. Markers, tags and labels shall use indelible ink or etching which will not fade in sunlight or in duct applications. Markers, tags, and labels shall not become brittle or deteriorate for 30 years. Label termination panels with cable number or pair identifier for cables in accordance with EIA TIA-606 and as specified. Include installation date to cable labeling and identify the labeling format and provide a complete record to the District with the final documentation. Identify each cable with type of signal being carried and termination points.

B. Affix identification and warning signs and tags to fiber distribution panels, terminal equipment, patch cords, and fiber optic cables.

C. Provide weatherproof warning tags to flag the presence of optical cables. Install such tags on or near optical cables, using distinctive tags to identify the cables, in the following locations:

1. Every 100 feet in underground track ways.

2. Every 10 feet in communications equipment areas.

3. At each location where optical cables enter or exit raceways of any sort.

4. On exposed conduit runs under station platforms or in plenums, at intervals of 50 feet.

5. At each manhole location along the communications wayside conduit bank runs.

3.04 SPLICING AND TERMINATION OF FIBER OPTIC CABLES

A. Make splices in fiber optic cable fibers only inside TCRs and TCHs, protected equipment rooms, or in accessible wayside splice enclosures. Submit a description of each type and location of splice that will be used, naming the materials, devices, tools, instruments, and other details.

1. All splices, including splices of pigtails to incoming fibers, shall be the fusion type. Apply protective covering and coating, made of compatible material, to all completed and tested splices.

2. Contain splices within re-enterable splice modules that are designed specifically to accommodate fiber splices and the prescribed extra lengths of fiber. Provide one or more splice modules for each system-wide 144-fiber cable as necessary and mount them in wall-mounted splice cases as indicated. Fibers that are required at each location as shown on the Contract Drawings shall be spliced to lateral fibers that connect to the fiber distribution panel in cabinet 92A.

3. If splices are not made immediately after cable installation, seal the free ends of such cables as recommended by the manufacturer to prevent entrance of moisture and contaminants.

4. Splices along the wayside shall be subject to the approval of the Engineer. Where allowed, make splices in outdoor weatherproof splice enclosures, complete with entry raceways, foundations, mounting hardware, secured access door, and exterior fittings.

5. Equip the interior of wayside splice enclosures with modules and fittings designed to organize the cables, splices, and prescribed extra length of fibers. Make provisions to add a renewable desiccant compound to protect against condensation or migration of water.

6. Optical Cable Terminations at TCRs/TCHs, Vent Structures and Portal Communication Cases (PCCs): Terminate all fibers at the fiber distribution panel within each TCR/TCH, vent structure, and PCC as follows:

    a. Terminate incoming optical fibers using matching single-mode optical fiber pigtail assemblies. Splice such optical fibers to the pigtail assemblies within a splice tray or trays.

    b. Assign and terminate incoming and outgoing optical fibers; spares that are designed to pass through the local site shall be spliced together within a splice tray or trays where designated splices are configured.

    c. Configure terminations to use the least number of splices feasible.

3.05 CATEGORY 6/6A CABLE AND PATCH CORD INSTALLATION

A. All backbone and horizontal Category 6/6A cable shall be terminated to Keystone style jacks. Maintain Manufacturer-recommended bending radius, pulling tension, and cable support requirements. Cables, wires, and equipment shall be securely and neatly installed. Inside routing shall be installed parallel and perpendicular to existing structural lines and members. Plastic or metal cable ties may not be used; only Velcro or Millipede ties may be used.

B. Category 6**/**6A data cabling shall be terminated in accordance with the TIA/EIA 568B sequence specification.

C. Category 6/6A patch cords shall be terminated in accordance with the TIA/EIA 568A or TIA/EIA 568B sequence specification.

3.06 CATEGORY 6/6A PATCH PANEL INSTALLATION

A. Mount patch panels into the designated rack, cabinet, or bracket locations. Surface mount or DIN rail patch panels may be used when the use of rack mount patch panels is not feasible. Category 6/6A industrial DIN rail housing field terminations shall be component compliant to EIA/TIA Category 6/6A performance requirements.

B. Keystone jacks are required for Category 6/6A cable terminations. Terminate the shielded or unshielded jacks as applicable and install into the patch panel according to manufacturer’s instructions.

C. Cable terminations shall have no tensile or bending strain on the installed shielded jacks.

D. Consolidation point equipment, where applicable, shall be fully installed and terminated prior to testing.

E. Panels shall be labeled on front and back with the cable number and port connections for each port. The panel grounding strap shall be installed to connect the cable shield and drain wire to the building signal ground in accordance with ANSI-J-STD-607-A.

F. Install Category 6 unshielded and Category 6A jacks grouped together on panel.

3.07 FIELD TESTS

A. The requirements for test planning, scheduling, performance, recording of data, and reporting of test results shall be as specified in Contract Specifications Section 20 72 25, Factory and Field Testing.

B. Fiber Optic Cable Reel Tests:

1. Fiber Optic Reel tests: Perform the following tests on fiber optic cable at the job site before it is removed from the cable reel. For cables with factory installed pulling eyes, these tests shall be performed at the factory and certified test results shall accompany the media. Perform optical time domain reflectometer (OTDR) tests with media on the reels and compare factory and field test data.

2. Reel Test Results: Provide results of reel tests to the District at least 10 working days before installation is to commence. Results shall indicate reel number of the media, manufacturer, type and number of fibers tested, and recorded readings. When reel tests indicate that the media does not comply with factory reel test results, remove the media from the job site and replace with compliant media.

C. Fiber Optic Cable Installation Tests:

1. Test all single mode and multimode fiber strands end-to-end for bi-directional attenuation, 850 nm/1300 nm for multimode and 1310 nm/1550 nm for single mode fibers. Conduct tests in compliance with EIA/TIA-526-14 or OFSTP 14, Method B, according to the manufacturer's instructions for the test set being utilized.

2. Tests must ensure that the measured link loss for each strand does not exceed the "worst case" allowable loss defined as the sum of the connector loss (based on the number of mated connector pairs at the EIA/TIA-568 B maximum allowable loss of 0.75 dB per mated pair) and the optical loss (based on the previously-specified performance standards).

3. After the cable is terminated, perform the following tests:

    a. After termination, test each fiber with an OTDR for length, transmission anomalies, and end-to-end attenuation. Perform the test with the following reference values for the loss length testing limits: MM 50 m: -19.4 to -26.5 dB, MM 62.5: -17.5 to -23 dB, and SM: -0 to -9 dbm.

    b. Insertion Loss: An OTDR shall be used to measure splice losses and identify events such as bad or dirty connectors, fiber bends, bad splices, and mismatched core sizes. Conduct the test in accordance with ANSI/TIA/EIA-455-34-A-2002, Interconnection Device Insertion Loss Test. Detected problems on a given link shall be corrected and then retested before proceeding with subsequent tests.

    c. Optical Power Loss (OPL) and Optical Return Loss (ORL): The specified multifunction loss tester shall be used to measure OPL and ORL on each link. The ORL shall be 20 dB minimum for multimode fiber and 26 dB minimum for single mode fiber.

    d. The maximum allowable attenuation for any splice or termination is 0.3 dB.

4. Review end faces of field terminated connectors with a fiber inspection scope following the final polish. Connector end faces with hackles, scratches, cracks, chips, or surface pitting shall be rejected and re-polished or replaced if re-polishing will not remove the end face surface defects. The recommended minimum viewing magnifications for connector ends are 100X for multimode fiber and 200X for single mode fiber.

5. Conduct surface inspection testing of each fiber connector using the DAISI interferometer. The return loss performance of UPC fiber optic connectors shall be 50 dB or higher. Surface inspection testing for manufactured connector pigtails provided with factory certification documentation is not required.

D. Fiber Optic Network End-to-End Testing:

1. General: End-to-end testing shall be performed for links that comprise two or more link segments that are connected via splices or patch cords. In each of the following tests, inspect and clean the fiber connectors before hooking them up to the test equipment. Test patch cords and patch panels shall also be cleaned. Tests shall be performed in both directions for each end-to-end fiber link.

2. Repeat the OTDR, OPL, and ORL tests specified in Section 3.07 herein.

3. Spectral Domain Measurements for UON cables: Use the specified optical spectrum analyzer to measure the following parameters in an end-to-end test of UON DWDM fibers. This test shall be coordinated with and supervised by The District.

   a. Chromatic dispersion (CD)

   b. Polarization mode dispersion (PMD)

   c. Spectral attenuation (multi-lambda)

E. Shielded Category 6/6A Patch Panel Testing:

1. Shielded category 6/6A patch panels shall be tested as part of the installed horizontal or backbone cabling system. Jacks and faceplates shall be assembled complete and properly mounted. Panels shall be terminated and fully dressed with proper cable management.

2. Each link or channel in the cabling system shall be identified and tested individually, using at minimum an industry standard level IIIE tester, capable of testing to TIA/EIA-568-C.2 field test requirements.

3. Each panel port in the cable channel or link shall be tested for the shielded category 6 parameters listed below:

WIRE MAP / CONTINUITY	LENGTH	INSERTION LOSS
NEXT	PSNEXT	ELFEXT
PSELFEXT	Delay and delay skew	Return loss

Legend:

ELFEXT Equal Level Far-End Crosstalk

NEXT Near End Cross Talk

PSELFEXT Power Sum Equal Level Far-End Crosstalk

PSNEXT Power Sum Near End Cross Talk

4. In addition to the above test parameters, the continuity of the cable shield and drain wire shall also be verified.

5. A “pass” indication shall be obtained for each channel or link, using at minimum a level IIIE tester that complies with TIA/EIA-568-C.2 field testing requirements.

F. Category 6/A Cable Testing:

1. General: Test pairs of all installed F/UTP wiring for full compliance with Category 6 and Category 6A UTP specifications regardless of intended use. Provide documentation of test results for conductor pairs of each cable. Perform testing using the specified Category 6/6A cable tester. Test results shall be approved by the District prior to cable activation for voice, video, or data applications.

2. Testing Parameters: Four pairs shall meet the following measured specifications. Inspect cables that do not meet the following specification and re-terminate or replace if necessary, to ensure compliance:

   a. Line map cables to verify pin-to-pin continuity, lack of opens, shorts, and/or polarity reversals.

   b. The characteristic cable impedance shall be 100 ohms plus or minus 15 percent at 1 MHz to 100 MHz.

   c. Mutual capacitance of any pair at 1 kHz shall not exceed 17 nF per 1000 feet.

   d. Ambient noise shall be less than or equal to 40 dB.

   e. Signal to noise ratio shall be greater than or equal to 7 dB.

   f. Cable length shall be less than or equal to 90 meters.

G. Multi-Conductor Copper Cable Testing: Insulation resistance test shall be performed on cables between each conductor to grounded shield and shield to ground. Cable manufacturer's recommended method and values shall be applied. The test shall be made after cable installation, but before splicing or terminating. If the splicing or terminating is not performed immediately after cable installation, a second insulation resistance test shall be made just before splicing or terminating. Each cable installation shall be tested after splices and terminations are complete. No equipment shall be connected to the cable system during tests. If any field tests fail, correct the deficiency and retest. If the test fails again, replace the cable segment.

END OF SECTION 27 13 01

SECTION 27 21 00

UNIFIED OPTICAL NETWORK

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Functional and performance requirements of Unified Optical Network (UON) system.

1.02 RELATED SECTIONS

A. Section 01 33 00, Submittal Procedures

B. Section 01 33 23, Shop Drawings, Product Data and Samples.

C. Section 01 43 00, Quality Assurance

D. Section 01 45 00, Quality Control

E. Section 01 78 23, Operation and Maintenance Data

F. Section 01 78 39, Project Record Documents

G. Section 01 78 44, Spare Parts and Maintenance Materials

H. Section 01 79 00, Demonstration and Training

I. Section 20 50 13, Raceways for Facility Services.

J. Section 20 70 19, Indoor Cabinets, Racks, Frames and Enclosures.

K. Section 20 72 25, Factory and Field Testing.

L. Section 20 80 00, System Integration Testing.

M. Section 26 05 26, Grounding and Bonding.

N. Section 27 13 01, Communication Cables and Related Equipment.

1.03 MEASUREMENT AND PAYMENT

A. The work specified in this Section will be paid for under the applicable Bid Items based on the locations where work is performed, as identified in the Form – Description of Bid Items, in accordance with Contract Specifications Section 01 20 00, Price and Payment Procedures.

1.04 REFERENCES

A. American National Standard Institute (ANSI):

ANSI C2 National Electric Safety Code (NESC).

B. California Electrical Code

C. Code of Federal Registration (CFR):

36 CFR Part 1191	Part of Federal Register, Volume 56, No. 14, the "Americans with Disabilities Act".

D. Electronics Industries Association (EIA):

EIA/ECA-310-E	Cabinets, Racks, Panels, and Associated Equipment
EIA 455-11-177A	Standards for Test Measurements and Inspection of Fiber Cables, Connectors and/or Other Fiber Optic Devices
TIA-530-A	High Speed 25-Position Interface for Data Terminal Equipment and Data Circuit Terminating Equipment
TIA-606-A	Administration Standard for the Telecommunications Infrastructure

E. Institute of Electrical and Electronic Engineers, Inc. (IEEE):

IEEE 802.3	Carrier Sense Multiple Access with Collision Detection
IEEE 802.1AD	Standard for Local and Metropolitan Area Networks - Virtual Bridged Local Area Networks, Amendment 4: Provider Bridges
IEEE 802.1D	Standard for Local and Metropolitan Area Networks Media Access Control (MAC) Bridges
IEEE 801.1Q	Standard for Local and Metropolitan Area Networks Virtual Bridged Local Area Networks (LAN) Tagging.

F. The Internet Society:

RFC 2475	An Architecture for Differentiated Services
RFC 2598	An Expedited Forwarding PHB
RFC 3247	Per-Hop Forwarding Behavior

G. Underwriters Laboratories (UL):

UL 1581	Standard for Safety Electrical Wires, Cables and Flexible Cords

H. Miscellaneous Optical Standards

ITU G.709	Interface for Optical Transport Network (OTN)
ITU G.975	FEC Encoding/Decoding Application
ITU-T G.798	Optical Transport Network Functionality Within Equipment

1.05 ABBREVIATIONS

BARTnet	BART Data Communications Network
BITS	Building Integrated Timing Supply
BLSR	Bi-Directional Line Switched Ring
CoS	Class of Service
DC	Direct Current
DCC	Data Communication Channel
DS	Digital Signal
DSC	Data Communication Channel
DSCP	Differentiated Services Code Points
DWDM	Dense Wave Division Multiplexing
ECN	Explicit Congestion Notification
GNE	Gateway Network Element
GPS	Global Positioning System
IP	Internet Protocol
IPP	IP Precedence
LAN	Local Area Network
MLPS	Multi-Protocol Label Switching
MM	Multimode
MSTP	Multiservice Transport Platform
NMS	Network Management System
OADM	Optical Add-Drop Multiplexer
OCC	Operations Control Center
ONS	Optical Network System

OSC	Optical Service Channel
OTN	Optical Transport Network
PHB	Per-Hop Behavior
PTC	Project Test Center
QoS	Quality of Service
RU	Rack Unit (1.75 ins)
SCADA	Supervisory Control and Data Acquisition
SDH	Synchronous Digital Hierarchy
SFP	Small Form-Factor Pluggable
SM	Single mode
SNMP	Simple Network Management Protocol
TCH	Train Control House
TCR	Train Control Room
TDM	Time Division Multiplexing
ToS	Type of Service
UAN	Unified Administration Network
UON	Unified Optical Network
UPSR	Unidirectional Path Switch Ring
VLAN	Virtual Local Area Network
VPN	Virtual Private Network
VRF	VPN Routing and Forwarding
VSS	Video Surveillance System
WDM	Wave Division Multiplexing
XFP	Small Form-Factor Pluggable (10 Gigabit)

1.06 BACKGROUND INFORMATION

A. The existing SONET-based BARTnet system is currently being replaced by a new unified optical network (UON) that is based on wave division multiplexing (WDM) technology. The UON system is comprised of four separate data streams: the video surveillance system (VSS) and access control system network called the security network, the unified administration network (UAN) including administrative data and

voice, BARTnet (the train control and communications data network) and the T1 network.

B. Refer to Contract Specifications Section 27 13 01, Communication Cables and Related Equipment, for product installation and testing requirements of the UON fiber optic cable network.

C. The UON shall use two fiber strands from single-mode fiber optic cables that connect to each of the WSX UON equipment nodes. The equipment shall be connected to these fibers to form a dual, alternating, collapsed ring, for the transport of voice, data and video services. The alternating nodes will be connected to single-mode fiber pairs from two different cables. Physical separation is gained by routing each cable in physically separated raceways. The dual ring structure shall operate in a self-healing, bi-directional ring configuration. Transmit and receive assignments shall be subject to automatic or manual reconfiguration, caused by a fault, or by intentional shut-down of a network element.

D. All network hardware shall be designated matching products to match equipment in the existing UON network. Accordingly, UON cabinet layouts shall be submitted for District approval and optical add-drop multiplexer (OADM) slot assignments are provided in Tables 2 through 4 in this Specification Section.

1.07 SYSTEM DESCRIPTION

A. The UON shall be a communications link that will tie all voice, video, and data subsystems together at the node installation sites. The subsystems include, but are not limited to, telephone, automatic fare collection, supervisory control and data acquisition, destination signs, video surveillance, and train control.

B. The dense wave division multiplexing (DWDM) system for the UON consists of 32 separate wavelengths with 100 GHz (0.8 nm) spacing in the C-band (1,530 to 1,565 nm). The DWDM wavelength plan, including network assignments, for the existing system is shown in Table 1. Three DWDM rings have been configured to provide service to the current BART system; a fourth ring is forecasted that will be deployed to provide service to the San Jose extension in the future.

C. The security (i.e., video and access control) network on each ring is configured such that separate wavelengths are assigned between each station node and Central. The security network bandwidth shall be 2 Gps (1Gps plus 1Gps Protected / Load sharing point-to-point links).

D. The BARTnet network on a given ring shares a single wavelength as shown in Table 1 and is associated with crossponder #1. The BARTnet network bandwidth shall be 0.5 Gps.

E. The UAN network on a given ring shares a single wavelength as shown in Table 1 and is associated with crossponder #2. The UAN network bandwidth shall be 0.5 Gps.

F. The T1 service, which can support up to 28 T1 channels between stations and Central and 28 inter-station links, operates on a single wavelength as shown in Table 1.

G. The UON is based on the Cisco ONS 15454 Multiservice Transport Platform (MSTP) which provides traditional time-division multiplexing (TDM) and SONET/SDH services ranging from DS-1/E1 to OC-48/STM-16, along with storage area network, Ethernet, and IP services in a single platform. IP services are connected from OADM nodes are connected to a Cisco Catalyst 6509 switch utiliziling layer 3 multi-protocol label switching (MPLS) VPNs. Each virtual private network (VPN) has its own unique forwarding table, known as a VPN routing and forwarding (VRF) that maintain route separation for each IP service.

TABLE 1 - DWDM WAVELENGTH PLAN

WAVELENGTH (NM)	**CISCO 32-CHANNEL PLAN**				**AD-1C**	**AD-2C**	**AD-4C**	**AD-1B**	**AD-4B**
	Ring 1	**Ring 2**	**Ring 3**	**Ring 4**					
1530.33	Security	Security	Security	*Security*	30.30	30.30	30.30	30.30	30.30
1531.12	Security	Security	Security	*Security*	31.10				
1531.90	Security	Security	Security	*Security*	31.90	31.90			
1532.68	Security	Security	Security	*Security*	32.60				
1534.25	Security	Security	Security	*Security*	34.20	34.20	34.20	34.20	
1535.04	Security	Security	Security	*Security*	35.00				
1535.82	Security	Security	Security	*Security*	35.80	35.80			
1536.61	Security	Security	Security	*Security*	36.60				
1538.19	Security	Security	Security	*Security*	38.10	38.10	38.10	38.10	
1538.98	Security	Security	Security	*Security*	38.90				
1539.77	Security	Security	Security	*Security*	39.70	39.70			
1540.56	Security	Security	Security	*Security*	40.50				
1542.14	Security	Security	Security	*Security*	42.10	42.10	42.10	42.10	
1542.94	Security	Security	Security	*Security*	42.90				
1543.73	Security		Security		43.70	43.70			
1544.53	Security		Security		44.50				
1546.12	Security		*Security*		46.10	46.10	46.10	46.10	46.10

TABLE 1 - DWDM WAVELENGTH PLAN									
WAVELENGTH (NM)	**CISCO 32-CHANNEL PLAN**				**AD-1C**	**AD-2C**	**AD-4C**	**AD-1B**	**AD-4B**
	Ring 1	**Ring 2**	**Ring 3**	**Ring 4**					
1546.92	Security		*Security*		46.90				
1547.72	Security				47.70	47.70			
1548.51					48.50				
1550.12	Currently unassigned				50.10	50.10	50.10	50.10	
1550.92					50.90				
1551.72					51.70	51.70			
1552.52					52.50				
1554.13					54.10	54.10	54.10	54.10	
1554.94					54.90				
1555.75					55.70	55.70			
1556.55					56.50				
1558.17	XPD-3	XPD-3	XPD-3	*XPD-3*	58.10	58.10	58.10	58.10	
1558.98	XPD-2	XPD-2	XPD-2	*XPD-2*	58.90				
1559.79	XPD-1	XPD-1	XPD-1	*XPD-1*	59.70	59.70			
1560.61	OC48-1	OC48-1	OC48-1	*OC48-1*	60.60				
15xx.x in the part number indicates the ordering wavelength of the card (example: 1530.33 = 30.3).									

Service Description	
OC48-1	T1
XPD-1	BARTnet
XPD-2	Unified administrative network
XPD-3	Fail-over / Disaster Recovery
Ring 1	Assigned to the K, C and R lines
Ring 2	Assigned to the M, W and Y lines
Ring 3	Assigned to the A and L lines; proposed for WSX nodes S06 and S20.

TABLE 1 - DWDM WAVELENGTH PLAN									
WAVELENGTH (NM)	**CISCO 32-CHANNEL PLAN**				**AD-1C**	**AD-2C**	**AD-4C**	**AD-1B**	**AD-4B**
	Ring 1	**Ring 2**	**Ring 3**	**Ring 4**					
Ring 4	Assigned to the SVRT Extension nodes								
Legend: AD - add/drop; XPD - crossponder.									

H. The headend OADM node for each ring is equipped with a gateway network element (GNE) to interface via a dual interface layer to the three local area networks (LANs) at Central; i.e., Security, BARTnet and the UAN. Each OADM node is also linked to a T1 service OADM node at Central. OADM nodes are connected in a dual ring, alternating link configuration using two single mode fiber pairs. The dual ring structure is required for availability purposes and shall operate in a self-healing bi-directional line switched ring (BLSR) configuration. Under normal operating conditions, both cables will provide a communications service path from alternating station nodes.

I. The UON shall be capable of providing automatic protection switching for link recovery in the case of failure. If a complete fiber optic cable break should occur, the system shall perform a loop-back operation, isolating the fault, and maintaining communications with all equipment that remains connected to the network. Should a major node failure occur, the network shall automatically create and startup a new configuration without the node. Upon restoration of the failed node, the network-switching algorithm shall support automatic startup and reconfiguration of the network with the restored node. All restoration times shall be limited to a maximum of 50 milliseconds. In addition to the above protection scheme, off-premises, fiber optic-based backup system shall also be provided.

1.08 INTERFACES WITH OTHER SYSTEMS

A. Interface requirements to the existing BART equipment and cable infrastructure in LMA shall be submitted to BART for approval to assess if additional LMA infrastructure is required to support the submitted requirement. If additional LMA infrastructure is required, BART will provide a cost estimate and timeline for material and BART labor will be provided to support the submitted interface requirement.

1.09 SUBMITTALS

A. Provide submittals in accordance with Contract Specifications Section 01 33 00, Submittal Requirements, Contract Specifications Section 01 33 23, Shop Drawings, Product Data and Samples, and Contract Specifications Section 01 78 44, Spare Parts and Maintenance Materials.

B. Provide manufacturer’s data sheets and descriptive information sufficient to determine compliance with these Specifications for the following:

1. OADM assemblies and related equipment.

2. Network management system.

3. Fiber and copper distribution panels and cables.

4. DC circuit breaker panels.

C. Provide detail drawings and technical data including list of equipment and material, including manufacturer's descriptive and technical literature, reliability performance charts and curves, catalog cuts, and installation instructions. Drawings shall show proposed layout and anchoring of equipment. System drawings shall show final configuration, including location, type and termination of inter-cabinet cables.

D. Manufacturer’s instructions: Where installation procedures, or any part thereof, are required to be in accordance with the recommendations of the manufacturer of the equipment being installed, submit printed copies of these recommendations for approval prior to installation. Submit operating instructions outlining the step-by-step procedures required for system operation including description of each subsystem in its operating mode. Instructions shall include the manufacturer's name, service manual, parts list, and a brief description of equipment, components, and their basic operating features. Submit maintenance instructions listing regular maintenance procedures, possible system failures, a troubleshooting guide for repairs, and simplified diagrams for the system as installed.

E. Operation and Maintenance Manuals: Submit O and M manuals in accordance with Contract Specifications Section 01 78 23, Operations and Maintenance Data.

F. Training Materials: Submit training materials in accordance with Contract Specifications Section 01 79 00, Demonstration and Training.

G. Spare Parts List: Submit a recommended spare parts list in accordance with Contract Specifications Section 01 78 44, Spare Parts and Maintenance Materials.

H. Record Drawings: Submit record drawings in accordance with Contract Specifications Section 01 78 39, Project Record Documents.

1.10 QUALITY ASSURANCE AND QUALITY CONTROL

A. Refer to Contract Specifications Section 01 43 00, Quality Assurance, and Contract Specifications Section 01 45 00, Quality Control, for hardware quality assurance requirements and IEEE STD 730 for software quality assurance requirements.

B. Products shall be manufactured by firms regularly engaged in manufacturing products described in this section.

C. Field testing shall be performed by persons having 5 or more years of relevant testing experience.

PART 2 – PRODUCTS

2.01 GENERAL

A. The UON equipment shall consist of the following products:

1. OADM assemblies.
2. Fiber distribution panels and patch cords.
3. DC circuit breaker panels.
4. Remote alarm blocks.
5. Equipment cabinets.

2.02 UON NODE EQUIPMENT

A. OADM Assemblies

1. OADM assemblies shall Designated Matching Product Cisco ONS 15454 SDH Multiservice Transport Platform (MSTP). OADM assemblies shall be fully functional with all the required equipment/component including fiber and copper patch panels; fiber storage shelf and shelf controlled cooling fan tray; timing, communications and control equipment; optical switch and OADM; air ramps; dual power supplies and miscellaneous components necessary to provide a fully functional assembly. Equipment shall include the following:

    a. Two ONS shelves and common equipment.
    b. Optical multiplexer modules.
    c. EtherNet crossponder modules.
    d. Pluggable modules (SFP and XFP).
    e. DS1 and DS3 electrical interface modules.
    f. Alarm collection remote.

B. OADM slot assignments at each location shall be as shown in Tables 2 and 3.

C. Patch Panels, Patch Cords, Splice Trays and Storage Shelves

1. Fiber patch panels shall be ADC, 2 RU LC patch panels, model # TFP-2UT00-000B or equal.
2. Fiber patch cords shall be LC to LC and LC to SC patch cords, length as required. Fiber zipcord (patchcord) and pigtail outer jacket size shall be 1.6mm by 3.5mm or equal.
3. Fiber splice trays shall have a 48 splice capacity with rear fiber cable and front pigtail access and shall be ADC Model # ADCP-90-341 (FMT-JTU termination and

splice panel) with FL1-M-NT (splice trays) or equal. Fiber storage shelves shall be ADC FMT-D-BS-000000-A00B or equal.

4. DSX-1 patch panels shall be Telect 010-2184-SHDB-3 or equal.

5. Cat 6 patch panels shall be 24 or 48 port panels, ADC model PP24/48AC6T or equal.

D. Cable Management: 1 RU and 2 RU cable management shall be DAMAC F533-1901/2 or equal. Vertical cable management shall be DAMAC F533-012-8 or equal.

E. DC Circuit Breaker Panels: DC circuit breaker panels shall be Newmar DST-20A or equal equipped with a minimum of ten A and B 48 VDC plug-in circuit breakers and a remote summary alarm module.

F. Cat 6 Patch Panels: Cat 6 patch panels shall be 24 or 48 port panels, ADC model PP24/48AC6T or equal.

G. Cable Management: 1U cable management shall be DAMAC F533-1901 or equal. Vertical cable management shall be DAMAC F533-012-8 or equal.

H. Network Management System (NMS) Network Switch Connections: Provide and install the following four NMS Category 6 cable connections to the TCR/TCH network switch:

1. Optical service channel (OSC) 1 and 2.

2. Data communication channel (DCC) 1 and 2.

I. Alarm Collection Remote: The alarm collection remote shall be equipped with 176 discrete inputs, standard wire-wrap terminals for alarm inputs with LAN connectivity and SNMP trap alarm reporting. The alarm collection remote shall be DPS Telecom Remote Alarm Block model # 176N or equal.

J. Cables and Connectors for LMA: Provide the cables and connectors to BART who will make the connections between the OADM and the existing head-in equipment.

2.03 SOFTWARE

A. The latest release of Cisco ONS 15454 software, complete with a CD and right-to-use license.

B. Cisco Quality-of-Service Toolset.

Table 2 – OADM #1 Slot Assignments

SLOT	CARD	DESCRIPTION
1	15454-OPT-AMP-17C=	ONS 15454 Optical Amplifier - 17dB Gain - C-Band
2	15454-AD-4C-58.1=	Optical mux module – 2 Chn – 100 GHz -1558.17 – 1560.61
3	15454-AD-1C-xx.x=	Optical mux module – 1 Chn – 100 GHz -15xx.xx (See Table 1)
4	15454 Blank Module Slot Filler	
5	15454 Blank Module Slot Filler	
6	15454 Blank Module Slot Filler	
7	15454-TCC3A=	Timing Communications Control Three
8	15454-OSCM=	15454 SONET Platform Optical Transmission Element
9	15454-AIC-I=	Alarm Interface Controller-International
10	15454-OSCM=	15454 SONET Platform Optical Transmission Element
11	15454-TCC3A=	Timing Communications Control Three
12	15454 Blank Module Slot Filler	
13	15454 Blank Module Slot Filler	
14	15454 Blank Module Slot Filler	
15	15454-AD-1C-xx.x=	Optical mux module – 1 Chn – 100 GHz -15xx.xx (See Table 1)
16	15454-AD-4C-58.1=	Optical mux module – 4 Chn – 100 GHz -1558.17 – 1560.61
17	15454-OPT-AMP-17C=	ONS 15454 Optical Amplifier - 17dB Gain - C-Band

Table 3 – OADM #2 Slot Assignments

SLOT	CARD	DESCRIPTION
1	15454-GE-XP=	Ethernet 20-GE / 2-10GE crossponder
2		
3	15454-GE-XP=	Ethernet 20-GE / 2-10GE crossponder
4		
5	15454 Blank Module Slot Filler	
6	15454-MRC-1-12=	Sonet Card
7	15454-TCC3A=	Timing Communications Control Three
8	15454-XC-VT=	VT1.5 Cross Connect
9	15454-AIC-I=	Alarm Interface Controller-International
10	15454-XC-VT=	VT1.5 Cross Connect
11	15454-TCC3A=	Timing Communications Control Three
12	15454-MRC-1-12=	Sonet Card
13	15454-GE-XP=	Ethernet 20-GE/2-10GE crossponder
14		
15	15454-DS1E1-56	56-Port DS-1/E1 Card
16	15454-DS1E1-56	56-Port DS-1/E1 Card
17	15454 Blank Module Slot Filler	

Table 4 – LMA OADM Slot Assignments

SLOT	CARD	DESCRIPTION
1	15454-40-SMR1-C= or 15454-40-SMR2-C=	40Chs Single Module ROADM with integrated Optical Pre or 40Chs Single Module ROADM with integrated Optical Booster Note – Card selection based on design build out requirement
2		
3		
4		
5	15454-10GE-XP=	Ethernet 4-10GE crossponder
6	15454-10GE-XP=	Ethernet 4-10GE crossponder
7	15454-TCC3A	Timing Communications Control Three
8	15454-OSCM=	15454 SONET Platform Optical Transmission Element
9	15454-AIC-I	Alarm Interface Controller-International
10	15454-OSCM=	15454 SONET Platform Optical Transmission Element
11	15454-TCC3A	Timing Communications Control Three
12	15454-10GE-XP=	Ethernet 4-10GE crossponder
13	15454-10GE-XP=	Ethernet 4-10GE crossponder
14		
15		
16		
17	15454-40-SMR1-C= or 15454-40-SMR2-C=	40Chs Single Module ROADM with integrated Optical Pre or 40Chs Single Module ROADM with integrated Optical Booster Note – Card selection based on design build out requirement

PART 3 – EXECUTION

3.01 UON ASSEMBLY AND CONFIGURATION

A. Perform factory tests in accordance with the requirements specified in Contract Specifications Section 20 72 25, Factory and Field Testing.

B. Follow the procedures for UON assembly, configuration and factory testing as outlined in Cisco's ONS 15454 Procedure Guide, R9.0 or later.

3.02 QoS DEPLOYMENT

A. Traffic Classifications:

1. Provide eight classes of traffic as follows:

   a. Voice (see below for minimum requirements).

   b. Video (steaming)

   c. Call-signaling (see below for minimum requirements).

   d. Network control

   e. Critical data – train control

   f. Bulk data – background data flows.

   g. Best effort – default

   h. Scavenger – DoS, worm mitigation class (less-than-best-effort).

2. Voice traffic requires 150 ms one-way, end-to-end (mouth-to-ear) delay, 30 ms of one-way jitter and no more than 1 percent packet loss. Provide strict priority servicing for voice traffic; the amount of priority bandwidth assigned for it shall take into account the VoIP codec, the packetization rate, IP/UDP/RTP headers (compressed or not) and Layer 2 overhead. Additionally, provisioning QoS for IP telephony requires that a minimal amount of guaranteed bandwidth be allocated to call-signaling traffic.

B. QoS Policies: QoS policies shall be implemented in hardware rather than software. Provide the following as a minimum:

1. Classification and Marking – Comply with standards RFC 2475, RFC 2598 and RFC 3247. Perform classifying and marking (with standards-based DSCP markings) as close to the source as technically and administratively feasible.

2. Policing and Markdown – perform policing as close to the source as possible.

3. Queuing – Provide queuing on every node that has a potential for congestion. As a guide, do not provision more than 33 percent of a link for realtime traffic and reserve at least 25 percent of a link for the default Best Effort class.

C. Requirements for Protocol Standards:

1. Layer 2 parameters - 802.1Q Class of Service (CoS) bits.

2. Layer 3 parameters - IP Precedence (IPP), Differentiated Services Code Points (DSCP) and IP Explicit Congestion Notification (ECN).

3.03 TIMING REQUIREMENTS

A. The existing UON employs a Building Integrated Timing Supply (BITS) distribution amplifier and two Network Time Protocol (NTP) servers linked to two Global Positioning System (GPS) stratum-1 servers which act as the District primary synchronization and timing reference sources. All UON equipment shall be configured to reference the District primary BITS and NTP services. Coordinate all timing requirements with BART's Network Engineering Group.

3.04 FACTORY TESTING

A. Perform factory tests in accordance with the requirements specified in Contract Specifications Section 20 72 25, Factory and Field Testing.

3.05 INSTALLATION

A. Installation shall include the following activities as a minimum:

1. Pre-installation inspection of available space and power, cable runs and conduits, device terminal blocks, documentation on device terminal block wiring, and testing performed by others.

2. Confirmation of the physical inventory data and pre-installation visual inspection of the equipment.

3. Post installation inspection of all equipment, mounting, cabling, and wiring.

4. Execution of equipment diagnostics to verify proper operations.

5. Records shall be maintained for all installation and test activities, and shall be delivered to the District upon request.

B. System components and appurtenances shall be installed in accordance with NFPA 70, manufacturer's instructions and as shown. Necessary interconnections, services, and adjustments required for a complete and operable signal distribution system shall be provided. Components shall be labeled in accordance with TIA 606-A. Penetrations in fire-rated construction shall be sealed with fireproof material.

C. Inter-cabinet cabling shall be installed in accordance with Contract Specifications Section 27 13 01, Communication Cables and Related Equipment and TIA/EIA 568-B. Cabling, distribution panels, and outlets shall be marked in accordance with TIA 606-A.

D. Install all inter-facility fiber cable as specified in Contract Specifications Section 27 13 01, Communication Cables and Related Equipment.

E. Equipment Racks. Install EIA standard equipment racks as shown in the Contract Drawings and in accordance with Contract Specifications Section 20 70 19, Indoor Cabinets, Racks, Frames, and Enclosures.

F. Develop all installation procedures in accordance with the standards defined in this Section.

G. Install all equipment required by this Section; this includes all grounding equipment, power supplies and power cables.

H. All grounding shall be in accordance with EIA, National Electric Code, and local standards, Contract Specifications Section 26 05 26, Grounding and Bonding, and BART drawing K001 in the Contract Documents. Ground each piece of equipment in accordance with the recommendations of the manufacturer. Isolate all signal grounds from the electrical protective ground except at a single common point.

I. Warning/ID Signs and Tags.

1. Affix identification and warning signs and tags to the fiber distribution panels, terminal equipment, patch cords and the fiber optic cables.

2. Provide weatherproof warning tags to flag the presence of optical cables. Install such tags on or near optical cables, using distinctive tags to identify the cables, every 10 feet in communications equipment areas.

3.06 FIELD TESTING

A. The requirements for test planning, scheduling, performance, recording of data, and reporting of test results shall be as specified in Contract Specifications Section 20 72 25, Factory and Field Testing, and Contract Specifications Section 20 80 00, System Integration Testing, including the following:

1. Verify field assembly, connections, terminations, and splices.

2. Perform inspection and testing of equipment grounds in accordance with Contract Specifications Section 26 05 26, Grounding and Bonding.

3. Verify functions of devices, modules, equipment, software, subsystems, assembled terminals, and networks (using simulated or actual interfaces).

4. Verify the UON fiber links that connect the OCC with OADM nodes. Refer to Contract Specifications Section 27 13 01, Communication Cables and Associated Equipment for all physical layer testing requirements.

B. As specified in Contract Specifications Section 20 72 25, Factory and Field Testing, the majority of the field testing will be performed at the PTC. Rack mount the OADM GNE assembly and provide the necessary ancillary equipment to make UON Ring fully operable including hardware and software to simulate the connectivity to the network equipment at Central. Upon completion of all UON testing at the PTC, relocate the OADM GNE to Central for installation by the District.

C. Test the entire UON to verify that the cables are properly installed, spliced and terminated. Verify that the insertion losses of all fibers in the network are within the specified limits.

D. Field acceptance tests shall consist of exercising each system function through its required operations, under simulated conditions, to prove that the installation complies with specified requirements. Follow the procedures for installation, turn-up, provisioning and acceptance of the UON nodes as outlined in Cisco's ONS 15454 Procedure Guide, R9.0 or later.

E. Upon completion of field testing at the PTC, provide testing support to the District as required to test the entire UON system in its final configuration.

END OF SECTION 27 21 00

SECTION 27 30 01

TELEPHONE SYSTEMS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Telephone system.

1.02 MEASUREMENT AND PAYMENT

A. Measurement: Telephone systems will be measured for payment as a lump-sum unit acceptably installed and tested for compliance.

B. Payment: Telephone systems, will be paid for at the Contract lump-sum price for telephone systems, or as part of the lump-sum price for Communications Work, as determined by the lump sum measurement specified above, as indicated in the Bid Schedule of the Bid Form.

1.03 DESCRIPTION

A. Telephone Systems shall include the following:

1. IP Telephony System
2. Emergency Telephone System
3. Fire Telephone System
4. Emergency Call Box System

1.04 REFERENCES

A. Americans with Disabilities Act (ADA):

1. ADA Standards for Accessibility Design

B. American National Standards Institute (ANSI):

1. ANSI ICC A117.1 Accessible and Usable Buildings and Facilities
2. NFPA 72 National Fire Alarm and Signaling Code
3. NFPA 101 Life Safety Code®

C. Federal Communications Commission (FCC):

1. FCC Title 47 CFR 15, Subpart B

D. Internet Engineering Task Force (IETF):

1. IETF — Traffic Classification and Quality of Service (QOS) Attributes for Diameter

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Functional description of each telephone system and purpose of all proposed test and diagnostic equipment.

C. Top-down documentation for all IP Telephony System software and firmware. The documentation shall include structured formats or top-level flow charts, functional descriptions, program listings, detailed design descriptions of all algorithms, flowcharts, program design languages or pseudocode, operating instructions, data base descriptions, program logic and data interface diagrams and descriptions, and hardware interfaces. The submittal shall include the following:

1. A functional description and overview of the software.
2. An inventory of all software programs and modules, cross-indexed and characterized as standard, modified standard, or custom.
3. A standard that software documentation released by the Contractor conforms to.
4. Documentation on standard software.
5. Documentation on modified standard programs.
6. Functional requirements document, design and specifications document, and program source code for custom-designed software.
7. Complete listing of the database documentation.
8. Complete description of all display formats.
9. Memory map charts of application programs.
10. A network dial plan.
11. Quality of service (QOS) requirements.

PART 2 – PRODUCTS

2.01 INTERNET PROTOCOL (IP) AND ANALOG TELEPHONE SYSTEM

A. IP Telephony System shall be a network-based Voice over Internet Protocol (VoIP) as specified in the Designated Matching Products (DMP) list. Call control and messaging server clusters shall be designed to fail over to geographically diverse servers.

1. IP network shall be configured for QOS to give voice and video traffic priority.
2. IP phones shall be configured to encrypt voice traffic.
3. Adequate IP network security shall be provided.
    a. Servers must run an approved security agent.
    b. Appropriate firewalls in place to prevent unauthorized access.
    c. Features shall include:
        1) Join Across Lines.
        2) Mobile Connect - Single Number Reach with single Voice Mail box.
        3) Mobility, transparent movement during ongoing calls.
        4) Unity Messaging.
        5) Presence.
        6) Emergency Responder.
        7) Unified Video Advantage.
        8) Operations Management Software shall include:
            a) Provisioning manager.
            b) Operations manager.
            c) Service monitor.
            d) Service statistics manager.
        9) Gateways shall be a DMP and geographically diverse for redundancy.

B. IP Telephony System Design:

1. The IP Telephony system shall be designed for console-less operation, with dial-up service from IP Telephony sets, manual ringdown service from White Courtesy Telephone sets, direct trunk line 911 connection from Emergency Call Box (ECB) locations, and public address access from selected IP Telephony sets. System shall provide wireless network access points for Designated Matching Products (DMP) for wireless IP phones.
2. The equipment shall be of digital solid-state, modular design, utilizing the same Unified Communications Manager with the latest hardware and software technologies available at the time of bid.

Existing Communication Servers are to be used if already in place in BART's network. BART's intent is to build a single Communications Manager cluster to provide call control and messaging for the entire system. Incremental growth may require placement of phones only, phones and gateways and additional server capacity. This will be determined by BART Communication Engineer based on specific circumstances.

3. The hardware and software design shall be such that incremental increases in station lines and trunks, and modifications of user data (adds, moves, or changes) may be easily accomplished without affecting service to any existing lines and trunks.

4. Dial-up Service: The system shall provide station to station direct dialing, capable of processing calls to/from any point in the District's telephone system. IP Telephony users shall be able to go off-hook and dial any network number, regardless of location or serving IP Telephony System, and the system shall automatically complete the call to a system telephone set or route it over network lines for switching by the existing main Private Automatic Branch Exchange (PABX) at Lake Merritt Station (LMA), whichever is applicable.

5. Courtesy Telephones (CT): Courtesy telephones shall provide communications between patrons and the Station Agent's booth.

    a. The telephone switch shall provide courtesy telephone service. These phones shall be installed to provide easy access to elderly and handicapped patrons in accordance with ADA requirements.

    b. Calls made from courtesy telephones shall be directed to the IP Telephony in the Station Agent's booth(s). If the Station Agent does not respond after 15 seconds or the line is busy, a two-chime code call shall be broadcast over the Station Public Address System. The code call shall be repeated every 15-seconds until the call is answered.

    c. Telephones in the elevators shall initiate the PA-code call without time delay. These calls shall be redirected to Central Control via the Emergency Telephone System if the Station Agent does not respond to the call within 30 seconds.

    d. Courtesy telephones shall be designed for hands-free speaker phone operation. A permanently affixed sign shall be provided at each telephone location indicating public phones to be used in case of emergencies if the Station Agent does not respond to courtesy telephone call.

    e. Courtesy telephones outside the elevators shall initiate the PA-code call without time delay. These calls shall be redirected to Comspec at Central Control via the PABX Telephone System if the Station Agent does not respond to the call within 30 seconds.

6. Emergency Call Box Telephones: The IP Telephony System shall be designed to provide the functions for emergency call box telephones as follows:

    a. The telephone circuits shall be supervised through the IP Telephony System equipment.

b. Lifting the handset in the Emergency Call Boxes shall initiate the IP Telephony System to direct the call to BART Police emergency 911 operations.

7. Power to components in the system needs to be protected to ensure operation in power outage. This includes network components such as ethernet switches, gateways and servers as well as the telephone instruments. IP telephones can be powered by:

   a. Power over Ethernet.

   b. Power injectors in the wiring closet.

   c. Power cubes for each telephone at the desktop.

   d. PoE ports and IP phones shall support Cisco Discovery Protocol or equal.

   e. Analog phones shall receive power from VG gateway or equal.

C. IP Telephony Servers and Gateways Requirements:

1. Rack mountable inside a communication equipment cabinet. Alternative mounting arrangements are acceptable subject to District approval. Physical dimensions, construction, mounting data (wall and/or floor), and enclosure locking mechanism shall be submitted.

2. Employ a four or five-digit dial plan compatible with BART standards. The software shall have an automatic routine that performs number analysis to the third digit. The software must determine if the number dialed is within the BART's IP network or off net. No access level (e.g. "9") shall be required to dial any network number.

   Interfaces to the Public Switched Telephone Network (PSTN) will be through Designated Matching Product (DMP) integrated service routers.

3. Cisco VG family analog phone gateways will terminate analog telephony devices. These gateways convert analog traffic to IP and are under the control of the communications Manager. They are to be placed at the nearest, practical wiring closet to the analog devices.

D. Telephone Sets.

1. Telephone types shall be as specified herein. Wall jacks shall be standard type RJ 45. Plugs shall be RJ-type. Locations of telephones along with the type of telephone and wall jacks to be installed in each location are as shown in the Drawings.

   Telephone sets installed at interlocking locations shall be housed in a stainless steel NEMA 4X enclosure.

2. Analog Telephone Sets:

    a. General Requirements:

        1) One-piece G6 type handset with hearing-aid compatible receiver and noise-canceling transmitter.

        2) Non-modular, 3 feet length, vandal-resistant, low-risk exposure handset cords.

        3) Dual-gong, electromechanical ringer.

        4) Audio gain control, with a range of +8 to +12dBA, via a handset-mounted thumbwheel.

3. IP Telephone Sets shall be a Designated Matching Product (DMP).

4. Station courtesy telephone sets shall be white in color and be a Designated Matching Product (DMP).

5. Elevator cab courtesy telephone sets shall be stainless steel and a Designated Matching Product (DMP).

6. Emergency call box telephone sets shall be a Designated Matching Product (DMP).

7. Digital telephone sets in wayside facilities shall be a Designated Matching Product (DMP).

8. Hands-free phone call buttons shall be extended 0.25 inches and not be flushed or recessed.

E. The Contractor shall develop and implement a Network dial plan that shall update the IP Telephony Systems currently in service and incorporate those which are being supplied as part of this Contract. This plan shall also integrate the new equipment with the current Direct Inward Dialing (DID) and BART Telephone Network Dial Plan. The proposed Plan shall be submitted to the District for approval prior to implementation.

F. Systems conforming to the above requirements shall be compatible with a Designated Matching Product (DMP) communications manager.

G. BART shall be placed on the PABX supplier’s mailing list to receive announcements of the discovery, documentation, and solution to software problems, new software releases, and other improvements that could be made to the software furnished with the IP Telephony systems. This information shall be made available for 15 years after Acceptance.

H. Network Requirement:

1. Contractor shall provide the following for switches and routers:

    a. High availability with dual switches and routers on campus distribution and core layers.

b. Quality of Service (QOS) parameters within VOIP areas.

c. Resource reservation protocol (RSVP) within WAN areas for heterogeneous networks.

d. Survivable remote site telephony (SRST) backup mechanism for direct inward dial (DID) office internet protocol private branch exchange (IPPBX).

e. Provide external Ethernet data service for ET, FT, and elevator CT, in the event that the unified optical network (UON) is unavailable.

2.02 EMERGENCY TELEPHONE (ET) SYSTEM

A. Existing System Description:

1. The ET system consists of telephone sets installed in stations; wayside facilities including train control houses, ventilation structures, and traction power facilities; along the trackway in Emergency Trip Stations. Emergency telephone sets in the Station shall be installed in or near the Platform Trip Stations, and in the Emergency Management Panel Room.

2. Lifting the handset at any emergency telephone location places the caller on an immediate connection with the LMA operator at Central Control and in the Station Agent's booth of the covering passenger station. Location of the calling party is displayed on the visual display at Central Control, and recordings are automatically made of the entire conversation.

3. Lifting the handset initiates one-way inbound signaling to Central Control. The calling party receives a "ring back" tone to indicate that the call to Central Control is ringing. The Central Control operator answers the call by depressing the flashing console selector button after lifting the red emergency telephone (ET) handset from its console hook. The ring back tone is removed when Central Control answers.

4. The Station Agent can also initiate a call to Central Control over the emergency telephone system.

2.03 FIRE TELEPHONE (FT) SYSTEM

A. Existing System Description:

1. The FT system shall meet the design configuration as indicated.

2. The FT system consists of telephone sets installed in 14 below grade Passenger Stations, at the middle of each platform, at mezzanine near the fire alarm panel, at emergency exits, and at street level Command Post. Jackboxes are installed at a Fire Radio Call Box, at cross passages in below grade wayside tunnels (Berkeley Hills Tunnel and Transbay Tube), and at fire hose or standpipe locations.

3. The FT system provides audio communication and visual signaling between handsets located at street level and on each side of platform level below ground and on each jackbox location. The system is a dedicated closed loop design where handset and jackbox locations on the “party line” can communicate with each other up to six (6) handsets simultaneously.

4. Lifting a handset from the hookswitch or plugging into a jackbox location turns on a normally off strobe light located above the telephone set, this in turn would begin to strobe at locations on the system. The light continues to strobe until all parties hang-up and remove handset from jackbox.

5. The handsets and strobe lamps are connected by a single communication cable providing conductors for both audio and signaling.

6. The fire telephone system and strobe lamps are battery powered under constant charge. In the event of loss of AC power, the batteries will have enough capacity to operate the system for 200 hours. The batteries and chargers are located in the Train Control Room.

B. FT System Requirements:

1. The fire telephone system shall be designed in accordance with the technical and operational requirements of the existing FT as described above.

2. Fire Telephone handsets shall be provided in underground stations as indicated. Jackboxes shall be provided in subways and tunnels as indicated.

3. Major components and devices for the FT system shall include the following:

   a. Telephone handsets with hook switch and portable handsets shall be of rugged and durable construction and intended for emergency applications. Handsets installed in station premises shall be either pole or wall mounted units. Portable handsets shall have a shoulder strap carrying case. The handsets shall be a push-to-talk amplified unit with an armored cord.

   b. Jackboxes shall be yellow in color and shall contain one standard telephone jack (tip, ring and ground sleeve). The box shall be weather resistant with a spring loaded or gravity-drop door. The jacks shall have corrosion resistant contacts (gold plated) and wired to a four-position terminal strip in the box.

   c. The batteries shall be sealed lead-calcium type designed with a life expectancy of twenty years. The battery charger shall be current limited with short circuit protection for 120 VAC input and filtered DC output. The battery shall be sized to provide full operation at room temperature for ninety minutes after loss of normal power.

   d. Telephone enclosures shall be weatherproof and constructed of die-cast aluminum. The enclosure shall be lockable with yellow color and mark with “TELEPHONE” on the door. Hardware, including straps for pole mounting shall be stainless steel.

e. The strobe lamps with a yellow colored dome shall be designed for surface or pole mounting. The housing shall be aluminum die-cast or stainless steel with stainless steel hardware. The flash rate of the lamp shall be 80 flashes per minute rated at 1,000 effective candlepower with a peak candlepower of 75,000.

f. Other miscellaneous materials including cables, conduit and fittings, pull boxes and termination blocks shall be as specified in Section 20 70 26, Common Materials and Methods for Electrical Systems, and Section 20 50 13, Raceways for Facility Services.

4. A connection shall be provided at each passenger station such that monitoring (recording) shall be possible at the LMA Central Control.

2.04 INTERCOM SYSTEM

A. An intercom system shall be provided at end-of-line Stations.

B. The intercom system shall provide communications between the Supervisor's Booth and the Employee Lounge/Break Room.

C. Communications between room locations shall be hands-free after initially pushing a call button.

D. The intercom unit in the Supervisor's Booth shall be provided with volume control adjustment.

E. The intercom unit in the Supervisor's Booth shall be a Desk-type, and in the Employee Lounge/Break Room shall be a wall-mounted unit.

2.05 EMERGENCY CALL BOX

A. Emergency Call Boxes (ECB) shall be located, as shown on site plans, for parking lots and parking structures to provide a direct line to BART Police Dispatch via the 911 emergency assistance feature of the Telephone switch.

B. Communications shall be hands-free after initially pushing a call button.

C. A blue light with emergency strobe will be provided at each ECB location.

D. ECB telephone, strobe light and housing will be weatherproof.

E. ECB housing will be provided with appropriate ADA approved signage.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Station wiring for telephone systems shall be four-pair telephone CAT 6 cables. Station and feeder cables shall not be spliced together.

B. The power source for telephone systems (except for the fire telephone system) shall be fed from the DC distribution power panel.

C. Keystone Jacks with DIN rail mount modules shall be implemented for CAT 6 cables inside the telephone system interface cabinet.

D. Quantity and approximate locations of telephone system equipment are shown on the Contract Drawings.

3.02 TESTING

A. Testing shall be performed in accordance with the requirements specified in Contract Specifications Section 01 45 24, Testing Program Requirements. The following tests shall be performed on each telephone system to demonstrate the above named features as applicable:

1. Station to station calling.
2. Station to trunk calling.
3. Trunk to station calls.
4. Initiate traffic to/from the system that shall activate the various progress and signaling signals/tones generated by the respective system:
    a. Dial tone.
    b. Station busy tone.
    c. All trunks busy (congestion) tone.
    d. Ring back tone.
    e. Station ringing.
    f. Distinctive ringing.
    g. Delayed ringing at LMA Central (90 seconds for Elevator intercom to ET system).
    h. Maintenance and Administration data is received, accepted, and transmitted in accordance with District and manufacturer’s specifications.
    i. Transmission and signal levels across interfaces with other systems and subsystems.

END OF SECTION 27 30 01

SECTION 27 31 17

PUBLIC ADDRESS SYSTEM

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Functional requirements of PA system

B. Performance requirements of PA system

1.02 RELATED SECTIONS

A. Section 01 33 00, Submittal Procedures

B. Section 01 33 23, Shop Drawings, Product Data and Samples

C. Section 01 43 00, Quality Assurance

D. Section 01 45 00, Quality Control

E. Section 01 78 23, Operation and Maintenance Data

F. Section 01 78 39, Project Record Documents

G. Section 01 78 44, Spare Parts and Maintenance Materials

H. Section 01 79 00, Demonstration and Training

I. Section 20 50 13, Raceways for Facility Services

J. Section 20 70 19, Indoor Cabinets, Racks and Enclosures

K. Section 20 72 10, General Requirements for Systems Work

L. Section 20 72 15, General Requirements for System Design

M. Section 20 72 25, Factory and Field Testing

N. Section 20 80 00, Systems Integration Testing

O. Section 27 13 01, Communication Cables and Related Equipment

P. Section 27 30 01, Telephone Systems

1.03 MEASUREMENT AND PAYMENT

A. The work specified in this Section will be paid for under the applicable Bid Items based on the locations where work is performed, as identified in the Form– Description of Bid Items, in accordance with Contract Specifications Section 01 20 00, Price and Payment Procedures.

1.04 REFERENCES

A. Acoustical Society of America:

1. S1 Standards on Acoustics
2. S2 Standards on Mechanical Vibration and Shock
3. S12 Standards on Noise

B. American National Standards Institute (ANSI):

1. ANSI S1.1 Acoustical Terminology
2. ANSI S1.4 Specifications for Acoustical Level Meters
3. ANSI S1.8 Preferred Reference Quantities of Acoustical Levels
4. ANSI S1.13 Methods for the Measurement of Sound Pressure Level in Air
5. ANSI S3.2 Standard for Measuring the Intelligibility of Speech over Communication Systems

C. Electronic Industries Association (EIA):

1. RS-160 Sound Systems
2. RS-174 Audio Transformers for Electronic Equipment
3. RS-276 Acceptance Testing of Dynamic Loudspeakers
4. RS-278 Mounting Dimensions for Loudspeakers
5. RS-299 Loudspeakers, Dynamic, Magnetic Structures and Impedance
6. RS-426 Loudspeakers Power Rating, Full Range
7. RS-438 Test for Measuring Stiffness of Loudspeaker Spiders
8. RS-446 Detail Specification - Illuminated and Non-Illuminated Pushbutton Switches
9. SE-103 Speakers for Sound Equipment
10. SE-104 Engineering Specifications for Amplifiers for Sound Equipment

D. Institute of Electrical and Electronic Engineers, Inc. (IEEE):

1. IEE 802.3af Power over Ethernet

E. California Occupational Safety and Health Standards (Cal OSHA)

1.05 ABBREVIATIONS

AC	Alternating Current
ACR	Auxiliary Communications Room
ADA	Americans with Disabilities Act
ALCU	Automatic Level Control Unit
BARTnet	BART Communications Network
dB	Decibel
dBA	A-Weighted Decibels
DC	Direct Current
DSU	Destination Sign Unit
E and M	Ear and Mouth
FCP	Fire Command Post
ICS	Integrated Control System
ICMP	Internet Control Message Protocol
ICS	Integrated Computer System
IP	Internet Protocol
IPPBX	Internet Protocol Private Branch Exchange
LAN	Local Area Network
PoE	Power over Ethernet
PSTN	Public Switched Telephone Network
OCC	Operations Control Center
PA	Public Address
PLC	Programmable Logic Controller
SAB	Station Agent Booth
SCADA	Supervisory Control and Data Acquisition
SLPA	Signage, Lighting and Public Address
SNMP	Simple Network Monitoring Protocol
SPL	Sound Pressure Level

SRST	Survivable Remote Site Telephony
TCR	Train Control Room
UON	Unified Optical Network
UPS	Uninterruptible Power System
VMS	Variable Message Sign
VSS	Video Surveillance System

1.06 SUBMITTALS

A. Provide submittals in accordance with Contract Specifications Section 01 33 00, Submittal Procedures, Contract Specifications Section 01 33 23, Shop Drawings, Product Data and Samples, and Contract Specifications Section 01 78 44, Spare Parts and Maintenance Materials.

B. Shop Drawings: Submit Shop Drawings including but not limited to the following:

1. Complete functional diagram of the PA system.
2. SPL coverage calculation, acoustical modeling, and performance test results for the station platform and concourse levels. Coverage calculations shall be performed at five feet above platform, and concourse floor levels. Speaker outputs shall be at calculated SPL (refer to 1.06 B calculation) at four feet from speaker center line.
3. Cabling, grounding, and shielding scheme in equipment cabinets.
4. Description of the purpose and function of proposed test and diagnostic equipment, and procedures for programming the voice and tone synthesizer for pre-recorded messages.
5. Proposed layout and anchoring of equipment.
6. Final configurations, including location, type, and termination of inter-cabinet cables.
7. Comprehensive list of equipment and materials.
8. Manufacturer’s descriptive and technical literature, catalog cuts, and installation instructions.
9. Reliability performance charts and curves.
10. If requested by the Engineer, a Design Review Meeting shall be held in a District facility for the Contractor to present the design submittal.
11. Submit Shop Drawings in accordance with Contract Specifications Section 01 78 39, Project Record Documents.

C. Manufacturer's instructions: Where installation procedures, or any part thereof, are required to be in accordance with the recommendations of the manufacturer of the equipment being installed, submit printed copies of these recommendations prior to installation. Submit operating instructions outlining the step-by-step procedures required for system operation including description of each subsystem in its operating mode. Instructions shall include the manufacturer's name, service manual, parts list, and brief description of equipment, components, and their basic operating features. Submit maintenance instructions listing regular maintenance procedures, possible system failures, a troubleshooting guide for repairs, and simplified diagrams for the system as installed.

D. Factory and Field Test Plans and Reports: Submit factory and field test plans and reports in accordance with Contract Specifications Section 20 72 25, Factory and Field Testing, and Section 20 80 00, Systems Integration Testing.

E. Operation and Maintenance Manuals: Submit O and M manuals in accordance with Contract Specifications Section 01 78 23, Operation and Maintenance Data.

F. Training Materials: Submit training materials in accordance with Contract Specifications Section 01 79 00, Demonstration and Training.

G. Spare Parts List: Submit a recommended spare parts list in accordance with Contract Specifications Section 01 78 44, Spare Parts and Maintenance Materials.

1.07 QUALITY ASSURANCE AND QUALITY CONTROL

A. Refer to Contract Specifications Section 01 43 00, Quality Assurance and Section 01 45 00, Quality Control, for hardware quality assurance requirements and IEEE STD 730 for software quality assurance requirements.

B. Products shall be manufactured by firms regularly engaged in manufacturing products described in this section.

C. Field testing shall be performed by persons having five or more years of relevant testing experience.

PART 2 – PRODUCTS

2.01 GENERAL

A. An acoustical modeling and test measurements shall be performed to verify conformance of the PA system design as indicated in ANSI S3.2 for intelligibility of speech and voice announcement requirements for a minimum Articulation Index of 0.80.

B. The acoustic modeling study shall include recommended locations and number of additional speakers necessary for the PA system to achieve an average of 20 dBA of headroom above background ambient noise level plus or minus 3 dB at five feet above floor level in accordance with ANSI S1.8 and S1.13. Perform site survey of PA speaker locations to determine the background noise ambient sound pressure level (SPL). The background ambient noise level shall be used to calculate the nominal sound pressure level (SPL) in accordance with ANSI S1.13.

2.02 FUNCTIONAL REQUIREMENTS

A. The PA system design shall satisfy the following general requirements:

1. All PA system equipment shall be powered from the 120 VAC Uninterruptible Power System (UPS).

2. All PoE devices shall comply with the IEEE 802.3af standard for PoE.

3. The PA system shall meet applicable provisions of the Americans with Disabilities Act (ADA).

B. The station PA system shall interface to existing PA equipment at Central using the Unified Optical Network communications network for the following functions:

1. Train arrival ADA announcements generated by the Integrated Computer System (ICS).

2. Live messages and pre-recorded message requests from the Operations Control Center (OCC).

C. Announcement Zones: The PA system shall be divided into two zones – platform and concourse; announcements shall be directed to these zones as follows:

1. The IP telephone in the station agent booth (SAB) shall have the capability to announce to a single zone or both zones.

2. Manual announcements made from any location other than those from the SAB shall be broadcast to both zones.

3. Automatic messages shall be announced to both zones.

D. Manual and Automatic Voice Announcements: The PA system shall be able to broadcast manual and automatic voice or tone announcements, as follows:

1. Manual voice announcements shall be allowed through the IP telephone system using the IP telephone sets in the following locations:

a. SAB.

b. Platform areas with the exception of those at the end-of-platforms.

c. Fire command post (FCP) in the station.

d. Police room.

e. Central Control.

2. Automatic voice and tone announcements shall be allowed from the following locations or subsystem:

a. Fire alarm manual pull station, located on the concourse level of a station, shall upon activation, initiate a prerecorded voice message to be repeatedly sent over the PA system of the affected station. This announcement, in English and other foreign languages as may be required by the District, shall warn patrons that all station escalators will stop. Calculate the time to stop as the time it would take a patron who just stepped onto the longest escalator in the station to reach the next level. The calculated length of this announcement will be submitted to the District for approval if it does not comply with the Escalator BFS Specification Section 14 31 00, 2.09 “Controller and Wiring” Section K.

b. In the event the station agent does not respond to an elevator service request, a one-time automatic service request announcement shall be made. This announcement shall be broadcast 90 seconds after a service request.

c. Unanswered phone calls or unsuppressed alarms at the SAB shall initiate a series of code calls in the form of chiming sounds. Chimes shall be initiated after 15 seconds of ringing for an unanswered call, instantly for call waiting, and 15 seconds of any alarm. The type of chimes shall be as follows:

1) Courtesy phone call unanswered - two chimes

2) IPPBX phone call unanswered - three chimes

3) SAB SCADA system panel alarm unacknowledged - four chimes

4) Seismic activity detected – six chimes.

d. Once initiated, chimes shall repeat every 15 seconds until suppressed. Phone call chimes shall be suppressed from the SAB or by answering from any other station phone. Alarms shall be suppressed from the SAB SCADA system control panel.

e. The PA system shall send a signal to the ICS when the PA system is in use to synchronize announcement of train destinations with other announcements.

f. The destination sign system, in conjunction with its display unit and PA system, shall initiate automatic voice announcements of train arrival or train departure, as required.

E. The IPPBX PA paging phone in the SAB shall allow selection of pre-recorded voice and tone messages for broadcast over the PA system. Messages can be one-time or continuous, with combined voice and tones.

F. The destination sign system, in conjunction with its display unit and PA system, shall initiate automatic voice announcements of train arrival or train departure.

G. The capability to display PA announcements on the destination sign units (DSUs) shall be provided but not implemented. This will require the use of real-time speech to text conversion.

H. Announcement priorities, from highest to lowest, shall be as shown in Table 1. Any announcement with a priority of two or lower shall be pre-empted by an announcement of higher priority. Preempted automatic announcements shall resume after a higher priority announcement is completed.

TABLE 1: PA ANNOUNCEMENT PRIORITIES

PRIORITY	SOURCE
1	FCP IPPBX phone
2	Fire alarm manual pull station
3	Code calls:
	• Seismic sensor
	• SAB annunciator panel alarm
	• Courtesy phone
	• IPPBX phone
4	Central Control (PA system activation and audio messages)
5	SAB IPPBX phone
6	Destination sign system
7	Platform IPPBX phones
8	Elevator service request.

I. Volume controls shall be provided in the SAB, offices, conference rooms, and staff rooms to silence speakers in each respective location.

2.03 PERFORMANCE REQUIREMENTS

A. The PA system shall be designed in accordance with EIA SE-104 and the following requirements:

1. Frequency Response: Plus or minus three dB over the frequency range of 30 Hz to 20 kHz, and plus or minus one dB or better over the frequency range of 250 Hz to 5000 Hz as measured from the SAB handset to the output of any speaker.

2. Total Harmonic Distortion (THD): Less than one percent over the frequency range of 30 Hz to 20 kHz measured at the output of any speaker.

3. Operating Performance: Ambient temperature between 0 degrees Celsius and 40 degrees Celsius, and relative humidity of 5 percent to 95 percent.

4. Headroom: Plus or minus 20 dB above nominal SPL, without increase in hum, noise, total harmonic distortion, or frequency response.

5. Hum and Noise: 80 dB below nominal SPL.

6. Power Capacity: 50 percent greater than power output at nominal SPL.

7. Ambient Noise Compensation: A minimum of four microphones shall be employed for ambient noise compensation on the platform and concourse levels. This may be accomplished by using microphones inside selected speaker housings or external microphones. The ambient noise compensation subsystem shall comply with the following requirements:

   a. Continuous adjustments from one second to five minutes for sampling of ambient noise conditions to provide a zero time delay for announcements.

   b. Automatic adjustment range: 10 to 30 dB.

   c. Sense channel: 250 Hz to 4 kHz +/- 1 dB.

   d. Sense hold on announcement.

   In addition to the above approach, volume level scheduling shall be deployed based on the average ambient noise profile for weekdays and weekend days.

2.04 INTERFACES WITH OTHER SYSTEMS

A. The PA system server interfaces to the BARTnet access switch in the station TCR.

B. The PA system server interfaces to the IPPBX telephone system; refer to Contract Specifications Section 27 30 01, Telephone Systems.

C. The PA system interfaces to the survivable remote site telephony (SRST) router that provides connectivity to Central via the public switched telephone network (PSTN) in the event that the BARTnet service is unavailable. Refer to Contract Specifications Section 27 30 01, Telephone Systems.

2.05 SPEAKER LAYOUT GUIDELINES

A. Speaker coverage shall include concourse areas, platform areas, men’s and women’s restrooms, staff rooms, and the Station Agent Booth (SAB). Coverage for platform areas shall extend for their full length.

B. Where practical, speaker enclosures and supporting conduits in public areas shall be of a recessed design.

C. Non-public areas shall have speaker enclosures located for efficient coverage without the need for high volume settings.

D. Speaker enclosure placement shall be coordinated with the reflected ceiling, lighting, surveillance camera, and signage designs.

E. In public areas, as a guideline, speakers shall be placed on 15 to 25-foot centers and arranged to give even coverage of all public areas with no objectionably high close-range spots. On the platform, speakers are mounted in the signage, lighting, and PA (SLPA) raceway at 15 to 20-foot centers.

F. Within enclosed areas, such as restrooms, break rooms, and corridors, one speaker per 350 square feet or fraction thereof shall be provided. Speaker spacing may be adjusted to coordinate with station architectural features such as arched ceilings.

G. Notwithstanding the specified spacing, the speakers shall be placed to meet the specified overall system performance.

2.06 SPEAKERS

A. Speaker units shall be a 70-volt system, include a factory assembled loudspeaker, and satisfy the following requirements:

1. A selectable audio power tap: 8-32 watts at 70 volts.

2. Frequency response: -30 Hz to 20 kHz nominal.

3. Average SPL level: 89 dB, 1 watt per meter average or better.

4. Speaker color: Default white or as indicated.

5. Speakers mounted within rooms shall employ an 18-gauge steel baffle. All other speakers shall employ a vandal-resistant, weatherproof housing with a metal baffle and a perforated stainless-steel grill.

6. Loudspeakers in the offices shall be provided with volume controls to silence speakers in each respective location.

7. Speakers shall be made by an approved manufacturer from the designated matching products (DMP) list.

8. Speakers installed outdoors exposed to the elements shall be weather resistant.

B. A voice and tone synthesizer shall be provided to conform to the following requirements:

1. Messages: Minimum of thirty voice messages with a 30-second maximum time limit per message.

2. Tones: Multi-frequency, constant or periodic.

3. Supervision: Provision for supervision or fault detection in accordance with NFPA 72.

4. Quality: Messages generated shall be from recording and storage of human voices.

5. Message Storage: Messages shall be stored in solid-state memory devices.

2.07 ETHERNET I/O DEVICE SERVER

A. The Ethernet I/O device server shall accept up to four contact closure inputs from SCADA and transmit status changes to the PA server via an Ethernet connection to the BARTnet access switch as shown. The Ethernet I/O device server shall be Perle Ethernet I/O device server model IOLAN DS1 D4 or equal.

2.08 PA SERVERS

A. The PA servers for the OCC and the station TCR shall be AtlasIED IP108 or equal.

2.09 PA AMPLIFIER

A. The PA amplifier shall be a digital, IP-addressable amplifier. The PA amplifier shall be an AtlasIED T9160 Titan Modular Mainframe amplifier or equal.

2.10 FIBER OPTIC AND CATEGORY 6 CABLES AND PATCH PANELS

A. Fiber optic and Category 6 cables, patch panels and related accessories shall conform to the requirements of Contract Specifications Section 27 13 01, Communication Cables and Related Equipment.

2.11 STATION AGENT'S BOOTH EQUIPMENT

A. The SAB shall be equipped with the following.

1. An IPPBX PA paging phone providing the following functions:

    a. Pushbuttons for zone announcements; one per zone, one for all-calls, and two for future zones. The pushbuttons shall latch and illuminate upon activation.

    b. Pushbuttons for control functions; one pushbutton to unlatch, one push button to silence code calls, and two spares.

    c. Pushbuttons and lamps conforming to 16 mm IEC style pushbuttons per NEMA Type 13 and EIA RS-446.

    d. Push pad for the select panel to activate pre-recorded messages from the voice and tone synthesizer.

    e. LED lamps and lamp test for pushbuttons.

    f. PA busy lamp indicating zone activation.

2. Loudspeaker: Mounted in the ceiling.

3. Loudspeaker Volume Control: Adjustable from 60 dBA SPL.

2.12 PA EQUIPMENT CABINETS

A. PA equipment cabinets shall conform to Contract Specifications Section 20 70 19, Indoor Cabinets, Racks, Frames and Enclosures.

2.13 FACTORY TESTS

A. Perform factory tests in accordance with the requirements specified in Contract Specifications Section 20 72 25, Factory and Field Testing, and the following requirements.

B. The factory test demonstration shall include the following equipment as a minimum:

1. A BARTnet PoE-enabled edge switch with six connected speakers.
2. Two IPPBX phones.
3. Both PA servers.
4. The Ethernet I/O device server.
5. One ambient noise microphone.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install PA speakers, cabinets, panels and associated raceways and cables in accordance with the Contract Drawings and Section 20 72 10, General Requirements for Systems Work. Cabling shall be installed in accordance with Contract Specifications Section 27 13 01, Communication Cables and Related Equipment.

B. Install inter-cabinet connections identified on the Contract Drawings. All equipment shall be powered from the local 120 VAC essential power panel.

C. Perform system configuration to provide proper communications between all PA system equipment, the BARTnet network and the existing PA console at the OCC.

3.02 SOFTWARE CONFIGURATION

A. Follow the manufacturer’s software configuration guides and the District’s direction to configure IP addresses for all equipment, the PA servers for the OCC, and the stations and the EtherNet I/O device server.

3.03 FIELD TESTS

A. Comply with the requirements in EIA RS-276 - Acceptance Testing of Dynamic Loudspeakers and RS-490 - Standard Test Methods of Measurement for Audio Amplifiers. Conduct field tests in four phases following the installation of all PA speakers, cabinets, panels and associated raceways and cables.

B. Phase 1 – Installation Verification: Verify the continuity and correct termination of all cabling using Contractor-prepared interconnection diagrams. Test all cabling in accordance with the requirements specified in Contract Specifications Section 27 13 01, Communication Cables and Related Equipment.

C. Phase 2 – PA Coverage and Speech Intelligibility Testing: Test the coverage and intelligibility of voice announcements within the passenger station. Tests shall be conducted with announcements made locally from the SAB and other IPPBX phones with access to the PA system. The methods used for the measurement of SPLs and intelligibility of speech and sound shall conform to the requirements of ANSI S1.13 - Methods for the Measurement of Sound Pressure Level in Air and S3.2 - Standard for Measuring the Intelligibility of Speech over Communication Systems. Verify system frequency response from handset to loudspeaker output at nominal SPL.

D. Phase 3 – Inter-System Testing: Perform inter-system testing; e.g., PA-fire alarm-telephone-SCADA and PA-IPPBX systems to verify that signals are correctly transferred between each system.

E. Phase 4 – Testing from the OCC: Verify connectivity to station and announcements from the OCC PA console.

END OF SECTION 27 31 17

SECTION 28 10 01

ACCESS CONTROL SYSTEMS

PART 1 – GENERAL

1.01 SECTION INCLUDES

This section covers Access Control System components to be installed between doors and BART intranet. It does not specify access cards/badges, security management system and electronic smart keys and locks.

1.02 RELATED SECTIONS

A. 01 45 24, Testing Program Requirements

B. 01 79 00, Demonstration and Training

C. 08 71 00, Door Hardware

D. 20 70 26, Common Materials and Methods for Electrical Systems

E. 20 50 13, Raceways for Facility Services

F. 01 33 00, Submittal Procedures

G. 01 45 00, Quality Control

H. 01 43 00, Quality Assurance

I. 01 33 23, Shop Drawings, Product Data, and Samples

J. 20 70 26, Common Materials and Methods for Electrical Systems

K. 27 13 01, Communication Cables and Related Equipment

L. Standard Drawing K001, Train Control and Communication Cabinets Power and Grounding Requirements

1.03 MEASUREMENT AND PAYMENT

A. Separate measurement and payment will not be made for work required under this Section. All costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work of this Contract.

1.04 REFERENCES

Electronics Industries Association TIA568-C Structured Cabling System

1.05 SUBMITTALS

A. Drawings, product information, and samples shall be submitted in accordance with Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples.

B. Where installation procedures, or any part thereof, are required to be in accordance with the recommendations of the manufacturer of the material being installed, printed copies of these recommendations shall be submitted and approved prior to installation.

C. Installation shall be performed by persons certified by product manufacturer on the specific product.

D. Operations and Maintenance manual shall be submitted for Contractor supplied access control system equipment in accordance with the requirements specified in Section 01 78 23, Operations and Maintenance Data.

E. A list of Contractor recommended spare parts in accordance with Section 01 78 44, Spare Parts and Maintenance Materials shall be submitted.

1.06 QUALITY CONTROL

A. Products shall be manufactured by firms regularly engaged in manufacturing products described in this section.

B. Installation shall be performed by a qualified and experienced installer.

C. Field testing shall be performed by persons certified by product manufacturer on the specific product.

D. Also refer to Sections 01 45 00, Quality Control and Section 01 43 00, Quality Assurance.

1.07 SYSTEM DESCRIPTION

A. Access control components are card reader, “request-to-exit” (REX) detector, electrified lockset, or electric strike, door contact to monitor intrusions, push bar in high-occupancy room for emergency exit, access control panels and power supplies installed within enclosures as indicated.

B. Access control components shall be integrated into one system.

C. Access controlled doors shall be hardwired to an access control panel located as indicated.

D. Access control panels shall be connected to the network switch as indicated. Programming will be done by the District.

PART 2 – PRODUCTS

Access control system components between doors and communication network shall be as follows:

A. Card Readers: To read smart card or ID badge presented for entry permission. They shall be Designated Matching Product (DMP) and:

1. Designed or customized to read the BART Only Smart Card (BOSC) format;

2. Tamper and water resistant;

3. Either wall switch size type, with slotted mounting plate and a single gang switch box, or a mullion size type, suitable for mullion-mounted door installation on single-gang J-box with mud ring or on any flat surface;

4. Flush mounted.

B. Request-to-Exit (REX) Sensors: shall detect motion in the room exit coverage area and then signal the access control system. Request-to-Exit detectors shall be Designated Matching Product.

C. Electrified locks or electric strikes as specified in Section 08 71 00, Door Hardware.

D. Push (Panic) bars: refer to Section 08 71 00, Door Hardware.

E. Energy Transfer Hinges: to pass low-voltage power from the hinge jamb to the electrified lock or electric strike (on a pair of doors) without having exposed wire. Each door with an electric lock or strike shall be equipped with one Designated Matching Product energy transfer hinge.

F. Steel Door Contacts: shall contain a hermetically sealed magnetic reed switch. The contact and magnet housing shall snap-lock into a 1-inch diameter hole. Housings shall be molded from flame-retardant ABS plastic. Door contact shall be Designated Matching Product.

G. Access Control Enclosures for controller and reader I/O boards shall be one or more Designated Matching Product wall-mount enclosures as required:

1. Configure the enclosure with a tamper switch, and remove included battery, battery bracket, power supply board, and transformer if any. A twelve-volt DC power source shall be from one power supply for all access control panels (ACPs).

2. Enclosure for a controller shall be of tile-mounting (low-density) type. An enclosure for reader I/O boards may be of rack-mounting (high density) type if more than two reader I/O boards are needed and if approved by the District.

3. Nameplates shall conform with Section 20 70 26, Common Materials and Methods for Electrical Systems. Name on plate shall be “ACP-Mx” for main panel(s), and “ACP-y” for reader I/O board panel(s) where “x” is a number between 1 and 9 if there are more than one main panel in the same site and “y” is a number between 1 and 9 if there are more than one I/O panel connected to the same main panel.

H. Main Access Control Panel shall consist of a controller and an optional Multiplexer in a low-density enclosure. The tile mounting shall be used for ease of wiring and troubleshooting.

1. Controller: Designated Matching Product controller with two serial ports to connect to access I/O board buses:

   a. One controller shall be in its own low-density enclosure so that the spare slot is reserved for a multiplexer.

   b. If approved by the District, another controller shall be used instead of a multiplexer where an Ethernet connection from the protected section to the security management server is more appropriate than a serial connection to the first controller.

   c. To retrofit ACP into a small space (e.g. at some traction power substations), a compact installation where a controller and two reader I/O boards are housed in a single high-density enclosure may be used if approved by the District.

2. Multiplexer: A Designated Matching Product 8-port multiplexer shall be used (in the second slot of the main ACP) if there are (or will be) three or more RS485 buses from the controller to access I/O boards.

I. Access I/O boards are reader I/O boards or alarm input boards. Relay output boards are not being used. They shall be in separate enclosure(s) from the main ACP.

1. Reader I/O Boards: one or more Designated Matching Product dual-reader I/O boards as required for the controller to monitor and control components on the doors. A maximum of two boards shall be installed in a low-density enclosure for tile mounting. Rack-mounting of up to nine (9) boards per enclosure may be used if approved by the District.

2. Alarm Input Boards: one or more Designated Matching Product input boards as required. They are used to monitor alarms and input where there is no additional input port available on existing reader I/O boards or where there is no reader I/O board installed. For example, an input from Door Contact on a door not controlled by the system.

J. Power Supplies: Overall solution shall comply with Standard Drawing K001 - Train Control and Communication Cabinets Power and Grounding Requirements. One Designated Matching Product power supply shall have:

1. Two voltages: 12VDC is for controller, access I/O boards and multiplexer; 24VDC is for door locks, REX, door contacts and card readers.

2. Designated Matching Product Power (Lock) Control Modules with fuse-protected, non-power limited outputs. Power control modules shall be able to configure for fire alarm interface (FAI) operation and fail-safe or fail-secure doors. The number of outputs needed to handle locks shall be sized to allow for expansion as warranted.

3. Designated Matching Product network communication module to enable remote monitoring of power supply status.

4. Input to the Power Supply shall be from an essential 120VAC source. If the essential power is not available, a Designated Matching Product line-interactive Uninterruptible Power Supply (UPS) with four-hour capacity is required.

5. A line conditioner is required if the power feed is from a non-communication (such as lighting or motor) electrical sub panel.

6. Nameplates shall conform with Section 20 70 26, Common Materials and Methods for Electrical Systems. Name on plate shall be “ACP-PSx” for power supply panel where “x” is a number between 1 and 9 matching that of the main panel.

PART 3 – EXECUTION

3.01 INSTALLATION

An installer not certified by product manufacturer may install locks, card readers, door contacts, REXs, cabling, power supply, and enclosures. The installer may also install controller and access I/O boards, but shall not power up without thorough inspection by a technician certified by product manufacturer for the specific product. The certified technician shall verify that wires are terminated correctly before turning on the power supply.

A. Submit a spreadsheet listing the names and locations of all access-controlled doors and doors fitted with door contacts. The District will assign ID numbers for each device and return the completed spreadsheet to the Contractor. In addition, the District will provide IP addresses for the main ACP and Power Supply network communication module.

B. Contractor shall identify and perform corrective measures to doors and frames that may require repair to ensure they will function properly. This shall include:

1. Fixing excess gap between the door and the jamb, latch bolts that do not fully engage, insufficient clearance between the door and the jamb, the floor causing the door to stick, improper balance causing the door to move without assistance, and auto door closer that do not completely close the door.

2. Providing for additional mounting reinforcement (i.e. metal mounting plate or metal brackets) to ensure structural integrity of the facility is not compromised.

3. Providing for any additional water-proofing measures to ensure the facility maintains its protection against external elements.

C. A non-keyed non-functioning rotating door knob shall be installed on non-controlled doors so that they could be opened only from within the secured area.

D. Card Readers shall be installed in a non-metallic, single gang surface mounted type box. All terminals for signal and LED lights in the card reader shall be wired and functionally tested.

E. Energy transfer hinge wiring on the back needs to have proper deburring to prevent wires from being damaged.

F. End-of-Line resistor packs shall be installed to applicable access control devices to provide supervision states (open, closed or faulted).

G. Power and grounding shall follow Facility Standard Drawing K001, Train Control and Communication Cabinets Power and Grounding Requirements. In particular, enclosures shall be mounted on fiberglass boards or unistruts for complete isolation from the concrete or steel type wall. Raceways terminated to the enclosures and associated power supplies and isolation type transformers shall be provided with isolated coupler or isolation fittings.

H. Cables between each controlled door and the associated ACP shall be routed as shown without any splices. All cables shall be installed complying with the requirements of Section 20 70 26, Common Materials and Methods for Electrical Systems, Section 20 50 13, Raceways for Facility Services, and Section 27 13 01, Communication Cables and Related Equipment. Network cable shall meet TIA568-C Structured Cabling System requirements and terminate to industrial jack and associated patch panel housing.

I. Cable trays shall be secured by at least one tamper-proof screw.

3.02 TESTING

A. Factory and field testing shall be performed in accordance with Section 01 45 24, Testing Program Requirements and as specified herein. Cables shall be tested for compliance with the requirements of Section 27 13 01, Communication Cables and Related Equipment.

B. A factory test of one ACP connected to a full complement of access-controlled door devices shall be performed to demonstrate correct operation as defined in these specifications.

C. Field functional testing shall be conducted by a technician certified by product manufacturer for the specific product in two phases following the installation of field devices, ACPs and interconnecting wires and cables.

1. Phase 1, Installation Verification: The correct termination of field wiring shall be verified using Contractor-prepared interconnection diagrams.

2. Phase 2, Access controlled doors to ACP Testing: Access control functions shall be verified by entering and exiting each access-controlled door to confirm that the door status is correctly displayed on a laptop computer connected to controller(s) via the Ethernet port. The laptop computer shall be equipped with the necessary application software to perform the functional tests.

D. Integration (End-to-End) Test: The Contractor shall provide support to the District in the testing from access-controlled doors to the security management server(s) and end-user interface (GUI).

3.03 TECHNICAL SUPPORT

Field technical support and assistance shall be provided to the District's integration testing and commissioning for the Access Control System. Recommendations shall be provided and troubleshooting shall be performed on issues and problems that may arise on Contractor provided and installed equipment, components and materials.

3.04 DEMONSTRATION AND TRAINING

Provide demonstration and training to the District's Operations and Maintenance personnel for Contractor-provided equipment in accordance with Section 01 79 00, Demonstration and Training.

END OF SECTION 28 10 01

SECTION 28 31 00

FIRE DETECTION AND ALARM SYSTEM

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Fire alarm control unit (FACU).

B. Manual fire alarm stations.

C. Automatic smoke detectors.

D. Automatic heat detectors.

E. Waterflow and valve position supervisory switches.

F. Fire alarm occupant notification appliances.

G. Auxiliary fire alarm equipment and initiating devices.

H. Fire alarm wiring and cables.

I. Enclosures for FACU panels.

J. Power supply 120V.

K. Fire alarm system installation.

L. Training sessions.

M. Training manuals and training aids.

1.02 RELATED SECTIONS

A. Section 02 41 19, Selective Structure Demolition

B. Section 07 84 00, Firestopping

C. Section 09 91 00, Painting

D. Section 20 50 13, Raceways for Facility Services

E. Section 20 70 26, Common Materials and Methods for Electrical Systems

F. Section 20 72 25, Factory and Field Testing

G. Section 26 05 24, Low Voltage Wires and Cables

H. Section 26 05 70, Electrical Cabinets and Enclosures

1.03 MEASUREMENT AND PAYMENT

A. Separate measurement or payment will not be made for the Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the Bid Schedule of the Bid Form, or incidental to the Work of the Contract.

1.04 REFERENCES

A. National Fire Protection Association (NFPA):

1. NFPA 70 National Electrical Code
2. NFPA 72 National Fire Alarm and Signaling Code
3. NFPA 101 Life Safety Code
4. NFPA 130 Standard for Fixed Guideway Transit and Passenger Rail Systems

B. Americans with Disabilities Act (ADA)

C. Underwriters Laboratories, Inc. (UL):

1. UL 268 Smoke Detectors for Fire Protective Signaling Systems

D. Factory Mutual System (FM)

E. National Electrical Manufacturers Association (NEMA)

1.05 REGULATORY REQUIREMENTS

A. California Code of Regulations (CCR):

1. Title 8, Cal OSHA
2. Title 19, Public Safety
3. Title 24, Part 2, California Building Code
4. Title 24, Part 3, California Electrical Code
5. Title 24, Part 9, California Fire Code

1.06 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures; Section 01 33 23, Shop Drawings, Product Data and Samples; and Section 01 78 23, Operation and Maintenance Data Manual for submittal requirements and procedures.

B. Shop Drawings: Submit Shop Drawings including but not limited to the following:

1. Complete descriptive data indicating UL listing for system components.

2. Complete sequence of operation of the system (system logic).

3. Control unit general arrangement, and connection wiring with individual wire numbers, and color code. Module legends shall show the module type and the input and output connections.

4. Layout plan view showing location of initiating devices and notification appliances with zone and device numbers. Conduit size, and routing with wire fill must be shown on the same drawing.

5. Connection details typical for each device to be installed.

6. Nameplate schedules indicating text for annunciation and labeling.

7. Area coverage drawings with spacing requirements for the initiating and indicating/notification appliances in accordance with the requirements and criteria specified in the applicable Codes and Standards.

8. Standby Battery size calculations.

9. Provide California State Fire Marshall (CSFM) Listing numbers for system components.

C. Product Data: Provide electrical characteristics and connection requirements.

D. Spare Parts List: The Supplier shall provide a recommended spare parts list for one-year operation, and pricing good for 90 Days from date of equipment delivery.

E. Reports: A certificate of compliance and other documentation, as required by latest NFPA 72, shall be provided at the times indicated therein. Complete and submit for acceptance the applicable and required information in the System Record of Completion as required by NFPA 72, Section 7.5.6.

F. FACU program and software for maintaining the fire alarm system and for making modifications to the system for the addition or removal of devices, control function changes, etc.

G. Testing Plan: Provide a testing plan for quarterly, semiannual, and annual maintenance with detailed instructions in accordance with NFPA 72, Chapter 14.

H. Record Documents: Submit Record Documents in accordance with Contract Specifications Section 01 78 39, Record Documents.

1.07 QUALITY ASSURANCE

A. General: Refer to Section 01 43 00 for Quality Assurance requirements and procedures.

B. Items of the fire alarm system shall be listed as a product of a single fire alarm system manufacturer under the appropriate category by the Underwriters Laboratories Inc. (UL), and shall bear the “UL” label. Control equipment shall be listed under UL category UOJZ as a single control unit. Partial listing will not be acceptable.

C. In addition to the UL-UOJZ requirement specified above, the system controls shall be UL listed for Power Limited Applications in accordance with California Electrical Code, Article 760. Circuits shall be marked in accordance with California Electrical Code, Article 760-22.

D. Components of the fire alarm system shall be listed by the California Department of Forestry and Fire Protection Office of the State Fire Marshal (CSFM).

E. When more restrictive requirements have been adopted by the local authority having jurisdiction (AHJ), the system shall comply with the local requirements.

1.08 INSTALLER AND MANUFACTURER QUALIFICATIONS

A. A company licensed by State of California as a fire alarm installer with a C-10 Contractor's license and specializing in installing the products specified in this Contract Specification with a minimum of five years documented experience.

B. Principal installation personnel shall have completed the system manufacturer's training courses on the equipment to be installed.

C. The fire alarm system supplier (FASS) shall be a specialty contractor or a manufacturer regularly engaged in the design and the installation of fire alarm systems and their related subsystems. For the purposes of this Section, a specialty contractor shall be interpreted to mean an organization that complies with the following criteria:

1. Employs personnel on this project who have successfully completed NFPA, National Institute for Certification in Engineering Technologies (NICET), or manufacturer’s training courses on general fire protection principles and practices.

2. Has performed work (including design, installation, startup, testing and maintenance) of similar or greater complexity on at least five previous projects.

3. Has been actively engaged in the type of work specified in this section for a minimum of five years.

D. For the purposes of this section, a manufacturer shall be interpreted to mean an organization that complies with the following criteria:

1. Manufactures at least 75 percent (as measured by equipment cost) of the hardware specified in this section and which is furnished for this project.

2. Complies with the preceding criteria established for a specialty contractor.

E. The FASS shall maintain a permanent, fully staffed and equipped service facility within 100 miles of the Jobsite. The service facility shall have full-time, NICET-certified employees qualified in the design, installation, testing, and servicing of the equipment and systems specified herein.

F. The FASS as a minimum shall be responsible for the technical supervision of the installation by providing on site supervision to the installers of the system.

1.09 MANUFACTURER'S FIELD SERVICES

A. Include services of factory or NICET (National Institute for Certification in Engineering Technologies) certified technician to supervise installation, adjustments, final connections, and system testing.

1.10 SPARE PARTS LIST

A. Provide the following spare parts list. Percentages will be taken from the total quantity installed for that device. The list will include but is not limited to the following:

	Part	Quantity
1	Automatic smoke detector	15 percent
2	Automatic heat detector	15 percent
3	Automatic smoke and heat detector base	15 percent
4	Automatic smoke detector tamper cover	10 units
5	Manual fire alarm pull station	15 percent
6	Manual pull station tamper resistant cover	10 units
7	Ceiling mounted speaker/strobe notification appliance	10 percent
8	Ceiling mounted speaker notification appliance	10 percent
9	Wall mounted speaker/strobe notification appliance	10 percent
10	Wall mounted strobe notification appliance	10 percent
11	Occupant notification tamper resistant cover	10 units
12	Monitor module	15 percent
13	Control module	15 percent
14	Six relay control module	3 units
15	Fire Alarm Control Unit with programming	1 unit
16	Keys of each type	12 units each

PART 2 – PRODUCTS

2.01 GENERAL REQUIREMENTS AND OPERATION

A. Provide an addressable, electrically supervised, manual and automatic, fire alarm and detection system, including proprietary and local alarm units, and occupant notification appliances.

B. Power supplies: Adequate to serve control unit modules, remote detectors, remote annunciators, smoke dampers, relays, alarm notification appliances, and other appurtenances as specified. Battery-operated emergency power supplies shall be furnished and sized with minimum 25 percent over the capacity required for the operating system in standby mode for minimum of 24 hours followed by alarm notification mode for 15 minutes per NFPA 72.

C. Performance and capacities of signaling line circuits shall be in accordance with NFPA 72, Class A; printer circuit in accordance with NFPA 72, Class E; initiating device circuits shall be in accordance with NFPA 72, Class A; and occupant notification circuits shall be in accordance with NFPA 72, Class A.

D. System Supervision: Alarm, trouble, and supervisory signals from intelligent reporting devices shall be encoded onto NFPA Class A Signaling Line Circuit (SLC). Alarm signals arriving at the fire alarm control unit shall not be lost following a power failure (or outage) until the alarm signal is processed and recorded.

E. Initiating Device Circuits (IDC): Supervised zone module with alarm and trouble indication; occurrence of an open condition shall place the circuit in trouble mode but shall not disable that circuit from initiating an alarm. Initiating device circuits shall be provided with Class A wiring.

F. Sprinkler system supervision circuits shall connect to the proprietary system transmitter via supervisory module for the tamper switches and valve position supervision switches with Class A wiring.

G. Occupant Notification Appliance Circuits: Supervised signal modules, sufficient for the indication/notification appliances connected to system; occurrence of an open or ground fault condition shall place the circuit in trouble mode but shall not disable any device on that circuit from signaling an alarm. Indicating appliance circuits shall be Class A wiring.

H. Auxiliary Relays: Provide sufficient double throw auxiliary relay contacts for each accessory function as indicated.

I. Trouble Sequence of Operation: System or circuit trouble shall place the system in the trouble mode, which shall cause the following system operations:

1. Visual and audible trouble alarm indicated by address at fire alarm control unit.

2. Manual acknowledge function at the fire alarm control unit shall silence the audible trouble alarm; visual alarm shall continue to be displayed and notification shall be maintained until initiating device failure or circuit trouble is cleared.

J. Alarm Sequence of Operation: Actuation of initiating device shall place the circuit in alarm mode, which shall cause the following system operations:

1. Sound and display local fire alarm notification appliances.

2. Transmit address alarm signal to control unit.

3. Indicate location of alarm address and type of device on fire alarm control unit.

4. Transmit signal by function to building mechanical systems as necessary and required for elevator control, escalator control, and other identified functions.

5. Alarm silence function at the fire alarm control unit shall silence audible alarm signaling devices; visual alarm shall continue to be displayed at the local fire alarm control unit, and notification via the network shall be maintained until alarm reset occurs. Actuation of a second initiating device shall cause the alarm to re-activate in accordance with this section.

K. Alarm Reset: System shall remain in the alarm mode until manually reset with key-accessible reset switch; system shall reset only if initiating circuits are out of alarm mode.

L. Lamp Test: Manual lamp test function shall cause alarm indication at each zone at fire alarm control unit.

M. Addressing: Actual room numbers and/or names will be assigned by the District and shall be shown on the Drawings. Control unit addressing shall include the address, room number or room/space name, type of address, and functions associated with the address.

N. Each fire alarm control unit shall have a minimum of 20 percent additional space for future expansion.

O. Each system shall be electrically supervised against open wire, shorts and ground faults in the initiating, and indication/notification circuits.

2.02 MANUFACTURERS

A. Acceptable Manufacturers:

1. Products described below and identified by product name, model number, or other manufacturer designation, are Basis of Design Products. Basis of Design Products establish the standards of type, function, dimension, in-service performance, physical properties, appearance, warranty, cost, and other characteristics required by the Contract.

2. Products of manufacturers not listed may be proposed for substitution, provided they are comparable to the products specified.

   a. If “No substitutions” is indicated next to the product name, provide only products of listed manufacturers.

b. The burden of proof of equality of proposed products is on the Contractor.

2.03 CONTROL UNITS

A. The main FACU and associated sub-assemblies shall be Notifier NFS2-3030 or equal, complete with power supply and the necessary components as shown below:

1. Central Processing Unit and Display.
2. Digital Voice Command.
3. Loop Control Module.
4. Loop Expander Module.
5. 75 Watt Amplifier.
6. Control Unit Power Supply.
7. Power Supply.
8. Batteries.
9. Enclosure.
10. Battery Box.
11. Seismic Mounting Kit.

B. The sub-fire alarm control unit (sub-FACU) and associated sub-assemblies shall be Notifier NFS-320 or equal. The sub-FACU shall be capable of being networked to the main FACU. The sub-FACU shall be addressable, capable of Class A SLC and NAC configuration, and have an 80-character display. The sub-FACU shall be equipped with a power supply and the required components to perform the functions specified and shown in the design, including but not limited to:

1. Control unit complete with backbox and power supply
2. Batteries
3. Seismic Mounting Kit

C. The FACU shall communicate with and control the intelligent detectors, intelligent manual pull stations, addressable modules, and other system controlled devices. The FACU shall perform the following functions:

1. Supervise and monitor the appropriate intelligent addressable detectors and addressable modules connected to the system for normal, trouble and alarm conditions.
2. Supervise the appropriate signaling and notification circuits.

3. Detect the activation of any initiating device and the location of the alarm condition for devices on the circuit. Operate notification appliances and auxiliary devices as programmed.

4. Visually and audibly annunciate any trouble, supervisory, or alarm condition on the unit display. Communicate such alarms via the fire alarm communication network.

5. Cause the signals, annunciation, and control of HVAC fans, elevators, escalators, and other equipment, as indicated in the Drawings.

D. System Capacity and General Operation

1. The FACU shall provide or be capable of expansion to 3,180 intelligent addressable devices, with up to 318 intelligent/addressable devices per loop. Each addressable loop shall have a minimum of 15 percent spare capacity and the FACU shall have a total of 30 percent spare capacity.

2. The FACU shall communicate with, monitor, and control other modules within the FACU. Removal, disconnection, or failure of any control unit module shall be detected and reported to the system display.

3. The FACU shall contain and execute control-by-event programs for specific action to be taken if an alarm condition is detected by the system. Such control-by-event programs shall be held in non-volatile programmable memory and shall not be lost with system primary and secondary power failure.

4. Each peripheral device connected to the FACU shall be continuously scanned for proper operation. Data transmissions between the FACU and peripheral devices shall be reliable and error free. The transmission scheme used should employ dual transmission or other equivalent error checking techniques. Failure of any peripheral device to respond to an interrogation shall be annunciated as a trouble condition.

E. Display

1. The complete system display shall provide the controls and indicators used by the system operator and may also be used to program system operational parameters.

2. The display shall be minimum 16 line, 640 character LCD backlit with a minimum of 11 LED indicators for system status and alarm conditions.

3. The display assembly shall contain, and display as required, custom alphanumeric labels for intelligent detectors, and addressable modules.

F. Signaling Line Circuit (SLC) Interface

1. Notifier Loop Control and Expander Modules: LCM-320 and LEM-320, or equal. The FACU SLC interface shall monitor and control intelligent addressable devices, including intelligent detectors and monitor or control modules.

2. The SLC interface shall not require any jumper cuts or address switch settings to initialize operations.

3. The SLC interface shall provide power and communicate with intelligent addressable detectors and modules on a single pair of wires. This SLC Loop shall be Class A wiring.

4. The SLC interface shall receive information from intelligent detectors and shall process this information to determine whether normal, alarm, or trouble conditions exist for that particular detector. The FACU/SLC interface shall include software to automatically maintain the detector's desired sensitivity level by adjusting for the effects of environmental factors, including the accumulation of dust in each detector. The analog information may also be used for automatic detector testing and for the automatic determination of detector maintenance requirements.

5. The SLC interface board shall communicate with each intelligent addressable detector and addressable module on its SLC loop and verify proper device function and status. Communication with intelligent devices shall be performed at time intervals consistent with the FACU Listing/Approval.

G. FACU/AMP Enclosure:

1. Notifier CAB-4 or equal. The control unit shall be housed in a UL listed cabinet. Enclosure and front shall be corrosion protected, given a rust-resistant prime coat, and manufacturer's standard finish.

2. The back box and door shall be constructed of steel with provisions for electrical conduit connections into the sides, top, and bottom.

3. The door shall provide a key lock and shall include a glass or other transparent opening for viewing of all indicators.

4. The control unit shall be modular in structure for ease of installation, maintenance, and future expansion.

5. The FACU and associated equipment shall be protected from the effects of voltage surges or line transients in accordance with UL 864 standards.

6. Each peripheral device connected to the FACU shall be continuously scanned for proper operation. Data transmissions between the FACU and peripheral devices shall be reliable and error free. The transmission scheme used shall employ dual transmission or other equivalent error checking techniques.

7. Provide seismic certification from manufacturers for equipment and enclosures. (Refer to ASCE7-10 section 13.2.2 2.)

8. Provide anchorage calculations and design details for enclosures and panels. (Refer to ASCE7-10 section 13)

H. FACU Power Supply

1. Notifier AMPS-24 or equal. The main power supply shall operate on 120 VAC, 60 Hz, and shall provide necessary power for the FACU.

2. It shall provide power necessary for proper operation of the occupant notification appliances. External power supplies shall be used to power the occupant notification appliances (strobes) as necessary.

3. It shall provide a battery charger and batteries for 24 hours of standby using dual-rate charging techniques for fast battery recharge.

4. It shall provide a very low frequency sweep earth detect circuit, capable of detecting earth faults on sensitive addressable modules.

5. It shall be power-limited per current UL 864 requirements.

6. It shall provide meters to indicate battery voltage and charging current.

7. A separate power supply shall be provided for externally controlled devices such as smoke dampers, remote relays, door holders, etc.

I. FACU Digital Voice Command

1. Notifier DVC-EM or equal. The digital voice command center located with the control unit, shall contain equipment required for audio control, emergency microphone system control, signaling, and supervisory functions. This shall include speaker zone indication and control, telephone circuit indication and control, digital voice units, microphone and main telephone handset.

2. The voice command center equipment shall perform the following functions:

   a. Operate as a supervised multi-channel emergency voice communication system. Audibly and visually annunciate the active or trouble condition of every speaker circuit.

   b. Audibly and visually annunciate any trouble condition for digital tone and voice units required for normal operation of the system.

   c. Provide all-call emergency paging activities through activation of a single control switch.

   d. Provide a factory recorded library of voice messages and tones in standard WAV. File format, which may be edited and saved on a PC running a current Windows® operating system.

   e. The digital voice command shall be modular in construction and shall be capable of being field programmable without requiring the return of any components to the manufacturer and without requiring use of any external computers or other programming equipment.

   f. The digital voice command and associated equipment shall be protected against unusually high voltage surges or line transients.

J. System Circuit Supervision

1. The FACU shall supervise circuits to intelligent devices, modules, horns, strobes, horn/strobes, speakers, speaker strobes, and any remote power supplies and shall annunciate loss of communications with these devices/appliances. The FACU shall continuously scan the devices for proper system operation. Upon loss of response from a device, an audible trouble shall sound.

2. Fire protection system valves shall be supervised for off-normal position.

K. Field Wiring Terminal Blocks

1. For ease of service, wiring terminal blocks shall be the plug-in type and have sufficient capacity for 16 to 12 AWG wire. Terminal blocks permanently fixed are not acceptable. The number of wires at each terminal shall not exceed two.

L. FACU Programming Features

1. The Contractor shall retain the services of factory certified technician for programming the FACU.

2. The system shall be programmable, configurable, and expandable in the field without the need for special tools or electronic equipment and shall not require field replacement of electronic integrated circuits.

3. Programming or editing of the program in the system shall be achieved without special equipment and without interrupting the alarm monitoring functions of the FACU.

4. Programming shall be accomplished through the standard FACU keyboard or through the video terminal.

5. Field defined programs shall be stored in non-volatile memory. The control unit shall maintain a history file of the last 4000 events, each with a time and date stamp. History events shall include all alarms, troubles, operator actions, and programming entries. The control panels shall maintain a 1000 event alarm history buffer, which consists of the 1000 most recent alarm events from the 4000-event history file.

6. The programming function shall be enabled with a password that may be defined specifically for the system when it is installed. Two levels of password protection shall be provided in addition to a key-lock cabinet. One level shall be used for status level changes such as zone disable or manual on/off commands. A second (higher-level) shall be used for actual change of program information.

7. System programming shall be capable of being backed-up on approved removable digital media (i.e. USB flash drive). This system back-up shall be capable of being downloaded to a replacement FACU system should the system be damaged due to fire or other event.

8. The Contractor shall turn over FACU passwords at the completion of programming or editing.

2.04 POWER SUPPLY FOR SPEAKERS

A. Notifier DAA2-7525 or equal. The digital amplifiers shall provide a minimum of 75 watts total output power at 25 VTMS and support two Class A high-level outputs.

B. Multiple audio amplifiers may be mounted in a single enclosure, either to supply incremental audio power, or to function as an automatically switched backup amplifier(s).

C. The audio amplifier shall include an integral power supply and shall provide built-in LED indicators to signal all required status, faults, operation, and alarm conditions.

2.05 POWER SUPPLY FOR STROBES

A. Notifier ACPS-610 or equal. The notification appliance power supply shall operate on 120 VAC, 60 Hz, and shall provide necessary power for the power supply.

B. It shall provide power necessary for proper operation of the occupant notification appliances (strobes). The power supply shall have a minimum of four (4) Class A, individually addressable outputs, each with a minimum output of 1.5 amps per circuit/output.

C. It shall provide a battery charger and batteries for 24 hours of standby using dual-rate charging techniques for fast battery recharge.

D. It shall provide supervision of the power supply and the associated circuits and communicate with the FACU via monitoring modules or similar devices.

E. It shall be power-limited per current UL 864 requirements.

2.06 ANNUNCIATOR

A. Notifier LCD-160 or equal. The annunciator shall be equipped with one (1) Notifier Annunciator Control Module ACM-24AT and with one (1) Notifier Annunciator Expander Module AEM-24AT, or equal.

B. The annunciator (including ACM and AEM modules) shall be housed in a secure, lockable enclosure with the screen and indicators visible without opening the door, Notifier ABS-4D(C), or equal.

C. The annunciator shall have a 640-character liquid crystal display with backlit control; be capable of remote control of the FACU; be capable of providing events and preprogrammed custom messages as displayed on the FACU; and a full screen with soft key functions.

2.07 SYSTEM COMPONENTS

A. Addressable Devices (General)

1. Addressable devices shall provide an address-setting means.

2. Alarm initiating devices shall be intelligent and addressable, shall be compatible with the FACU, and shall connect to the FACU signaling line circuits.

3. Addressable devices shall provide an address setting means.

4. Detectors shall be intelligent and addressable, shall be compatible with the FACU, and shall connect to the FACU signaling line circuits.

5. Smoke detector sensitivity shall be set through the FACU and shall be adjustable in the field through the field programming of the system.

6. Detectors shall automatically compensate for dust accumulation and other slow environmental changes that may affect their performance. The detectors shall be listed by UL as meeting the calibrated sensitivity test requirements of NFPA 72.

7. The detectors shall be ceiling-mounted and shall include a separate twist-lock base that includes a tamper proof feature.

8. The detectors shall provide a test means whereby they will simulate an alarm condition and report that condition to the FACU. Such a test may be initiated at the detector itself or initiated remotely on command from the control unit.

9. Detectors shall store an internal identifying type code that the control unit shall use to identify the type of device.

B. Addressable Manual Pull Station

1. Manual pull stations shall be Notifier NB-12LX, Notifier N-MPS, or equal, compatible with the FACU. Manual pull stations shall, on command from the FACU, send data to the control unit representing the state of the manual switch and the addressable communication status. They shall use a manually operated test-reset keylock and shall be designed so that after actual emergency operation, they cannot be restored to normal use except by the use of a hex key wrench or similar tool. Manual pull stations shall be provided with a non-alarming anti-tampering assembly, Safety Technology International (STI) Stopper II, or equal.

2. Manual stations shall be constructed of cast metal or plastic with clearly visible operating instructions provided on the cover. The word FIRE shall appear on the front of the stations in raised letters.

3. Stations shall be suitable for flush or semi-flush mounting as shown on the plans and shall be installed such that the operable part is 42 inches to 48 inches on center above the finished floor.

4. A permanent label identifying the pull station address shall be provided on each pull station.

C. Addressable Photoelectric Smoke Detector

1. Photoelectric detectors shall be Notifier FSP-851 or equal, compatible with the FACU. The detectors shall use the photoelectric principal to measure smoke density and shall, on command from the control unit, send data to the control unit representing the analog level of smoke density. Smoke detectors installed in public restrooms shall be provided with an anti-tampering and protective assembly, Safety Technology International (STI) Smoke Detector Damage Stopper-Steel, Steel Web Stopper for Smoke Detectors, or equal.

2. The smoke detectors shall be profiled for office or duct (as necessary and appropriate).

3. A permanent label, legible from the floor level, identifying the detector address shall be provided on each detector base.

D. Addressable Heat Detector

1. Heat detectors shall be Notifier FST-851 or equal, compatible with the FACU. The detectors shall use the rate-of-rise and fixed temperature principals to measure heat.

   EXCEPTION: Heat detectors installed in escalator machinery spaces accessed from the exterior of the Station shall be Notifier 302-AW-135 Rate Anticipation, all weather vertical mounting 135 degrees Fahrenheit, or equal, mounted in a NEMA 4 box. The device shall be capable of immediate response; self-restoring; hermitically sealed, shock resistant, corrosion resistant, and tamper-proof.

2. The heat detectors shall be fixed temperature of 135 degrees Fahrenheit and 15 degrees Fahrenheit per minute rate-of-rise.

   EXCEPTION: Heat detectors installed in escalator machinery spaces accessed from the exterior of the station.

3. A permanent label, legible from the floor level, identifying the detector address shall be provided on each detector base.

E. SUB-FACU Photoelectric Smoke Detectors

1. Photoelectric detectors shall be System Sensor i3 2W-B, or equal, compatible with the FACU. The detectors shall use the photoelectric principal to measure smoke density.

2. A permanent label, legible from the floor level, identifying the detector zone and device number shall be provided on each detector base.

3. Photoelectric smoke detectors shall be arranged in a cross-zone fashion using two alarm initiating device circuits.

F. Sprinkler Waterflow and Valve Position Supervisory Switches

1. Existing waterflow and valve position supervisory switches for the sprinkler system shall be connected to the FACU using compatible monitor modules.

2. When operated, an alarm signal shall be initiated at the FACU.

3. A permanent label, legible from the floor level, identifying the address shall be provided on each device as shown on the Drawings.

G. Monitor Modules

1. Monitor modules shall be Notifier FMM-1, FDM-1, or equal, compatible with the FACU. Modules shall, on command, from the FACU, send data to the control unit representing the state of the module and the addressable communication status.

2. Monitor modules shall be mounted on the wall, adjacent to the monitored device.

3. A permanent label, legible from the floor level, identifying the address shall be provided on each device as shown on the Drawings.

H. Control Modules

1. Control Modules shall be Notifier FRM-1, FCM-1, FDRM-1, XP6-R, or equal, compatible with the FACU. Modules shall, on command, from the FACU, send data to the control unit representing the state of the module and the addressable communication status and perform the intended function.

2. Control modules shall be located no greater than 3 feet from the component controlling the device.

3. A permanent label, legible from the floor level, identifying the address shall be provided on each device.

I. Occupant Notification Appliances

1. Occupant notification appliances shall be System Sensor, L-Series, or equal, compatible with the FACU. Strobes shall have a plug-in design; protective cover to reduce ground faults; mounting plate with onboard shorting spring for testing wiring continuity; and field selectable candela settings of 15, 30, 75, 95, 110, 135, and 185 candelas. Speakers shall have a plug-in design; protective cover to reduce ground faults; mounting plate with onboard shorting spring for testing wiring continuity; and a rotary switch to control speaker power with settings of 1/4, 1/2, 1, and 2 watts.

2. Strobes: ADA and NFPA 72, compatible with the FACU, field selectable candela values, strobe light with red lettered “FIRE” on white cover plate, System Sensor L-Series, SCWL, SWL, or equal.

3. Combination horn/strobes: ADA and NFPA 72, compatible with the FACU, field selectable candela values, strobe light with red lettered "FIRE" on white cover plate, System Sensor L-Series, P2WL, PC2WL, or equal.

4. Speakers: ADA and NFPA 72, compatible with the FACU, field selectable candela values, strobe light with red lettered "FIRE" on white cover plate, System Sensor L-Series, SPCW8, SPWL, or equal.

5. Combination speaker/strobes: ADA and NFPA 72, compatible with the FACU, field selectable candela values, strobe light with red lettered "FIRE" on white cover plate, System Sensor L-Series, SPSCWL, SPSWL, or equal.

6. A permanent label, legible from the floor level, identifying the address shall be provided on each appliance.

7. Notification appliances installed in public restrooms shall be provided with an anti-tampering and protective assembly, Safety Technology International (STI) Smoke Horn/Strobe/Speaker Damage Stopper, Stopper Dome, or equal.

2.08 BATTERIES AND POWER SUPPLY

A. Battery

1. Notifier BAT-12550 or equal. Batteries shall be 12V.

2. Battery shall have sufficient capacity to power the fire alarm system for not less than twenty-four hours plus 15 minutes of alarm upon a normal AC power failure.

B. Power Supply

1. Provide Power Supplies as specified in Articles, 2.02H, 2.03, and 2.04.

2. Shall be completely automatic, with constant potential charger maintaining the battery fully charged under all service conditions. Charger shall operate from a 120V 60Hz source.

3. Shall be rated for fully charging a completely discharged battery within 48 hours while simultaneously supplying any loads connected to the battery.

4. Shall have protection to prevent discharge through the charger.

5. Shall have protection for overloads and short circuits on both AC and DC.

2.09 FIRE ALARM WIRE AND CABLE

A. Wiring shall be installed in a continuous galvanized rigid steel (GRS) conduit system. Conduits shall be concealed, to the extent practical and feasible. Conduit and wire shall be in accordance with the California Electrical Code (CEC), NFPA 72, and NFPA 130, Chapter 12.

1. Cable and wiring meeting the requirements of NFPA 72, Chapter 12 of NFPA 130, and the California Electrical Code may be installed in concealed spaces (e.g. above ceilings). Cable and wire shall not be installed in ventilation ducts. Fire alarm cabling and wiring shall be in GRS conduit.

2. Conductors shall be fire/smoke rated in accordance with the requirements of Chapter 12 of NFPA 130.

3. Conductors shall be labeled at each end.

B. Conduit/Raceway:

1. Wiring shall be installed in conduit or raceway. Raceway fill shall not exceed 40 percent of interior cross-sectional area where three or more cables are contained within a single conduit.

2. A fire alarm riser diagram indicating type and quantity of devices and size and quantity of conductors and conduits, shall be submitted for approval.

3. Cable must be separated from any open conductors of Power, or Class 1 circuits, and shall not be placed in any conduit, junction box or raceway containing these conductors, as per NEC Article 760-29.

4. Wiring for 24V control, alarm notification, emergency communication, and similar power limited auxiliary functions may be run in the same conduit as initiating and signaling line circuits. Circuits shall be provided with transient suppression devices and the system shall be designed to permit simultaneous operation of circuits without interference or loss of signals.

5. Conduit shall not enter the fire alarm control unit, or any other remotely mounted control unit equipment or back boxes, except where conduit entry is specified by the manufacturer.

6. New conduit shall be 3/4 inch minimum.

7. No conductor or cable splices shall be permitted.

8. Provide type and spacing of the fasteners specified/designed for installation of fire alarm devices and conduit installation so that it is within the exception limit of seismic requirements. (Refer to ASCE7-10 section 13.4.5.)

C. Wire

1. Fire alarm system wiring shall be new.

2. Wiring shall be in accordance with the California Electrical Code, Article 760, NFPA 72, Chapter 12 of NFPA 130, and as recommended by the manufacturer. Number and size of conductors shall be as recommended by the fire alarm system manufacturer.

3. Wire and cable shall be CSFM listed for use with a protective signaling system. Wire and cable not installed in conduit shall have the fire resistance rating suitable for the installation as indicated in the California Electrical Code and shall be supported and protected in accordance with the California Electrical Code and the manufacturer's requirements.

4. Field wiring shall be supervised. In the event of a primary power failure, disconnected standby battery, removal of any internal modules, or any open circuits in the field wiring; a trouble signal will be activated until the system and its associated field wiring are restored to normal condition.

D. Terminal Boxes, Junction Boxes, and Cabinets

1. Boxes and cabinets shall be UL listed for their use and purpose.

2. Fire alarm boxes, conduit body covers, and cabinets shall be painted red.

E. The FACU shall be connected to a separate dedicated branch circuit with a maximum 20 amperes. This circuit shall be labeled at the main power distribution panel as FIRE ALARM. Fire alarm control unit primary power wiring shall be 12 AWG.

2.10 SCADA INTERFACE, DRY CONTACTS, AND REMOTE MONITORING

A. **SCADA Points to Operation Control Center (OCC).** Provide an interposing relay cabinet (IRC) with 3 six-relay modules XP6-C next to CAB44. The relays shall be programmed to send the following signals to OCC:

1. Fire Alarm Summary

2. Fire Alarm System Malfunction

3. Manual Pull Station

4. Waterflow

5. Water Valve Closed

6. 480V Switchgear Room

7. Train Control Room

8. Concourse Level

9. Upper Platform Level or Platform if only one level

10. Lower Platform Level (If applicable)

11. Substation (If applicable)

12. Public Address (PA) Preemption

    The public address preemption relay shall suppress all automatic messages, but continue to allow manually operated messages through the PA system.

B. **Dry Contact to Station Agent Booth (SAB).** Provide 1-relay module next to the Supervisory Cabinet in the SAB. The relay shall be programmed to activate on a fire alarm for fare gate and emergency barrier release.

C. **Remote Monitoring System (RMS).** Provide all infrastructure for remote monitoring of the fire alarm system between the FACU and the train control room. Provide an ethernet connection when the distance is less than 250 feet or else provide 6 strands multimode fiber connected to the fiber entry cabinet. Coordinate with the District for connection to CAB100.

2.11 ENCLOSURES FOR FACU/AMP PANELS

Additional enclosures for main fire alarm panels and control equipment are required due to the dusty environment conditions within the control rooms.

A. Additional Enclosures for FA Control Units and Relay boxes:

1. Standard wall-mounted electrical enclosures from sheet metal shall be provided for additional protection.

2. For locations with size restrictions the internal battery enclosures can be mounted outside next to the main enclosure for the FA control units and the main enclosure can be reduced in size to utilize the space only needed for the main FA control units.

3. NEMA Rating shall be at minimum NEMA 4. (Due to the very dusty environment enclosures with gasket sealing and tight doors are required.)

4. Viewing Windows: Each door of the main control unit enclosures shall be equipped with a window big enough to view the main control panels annunciations and status monitors and to show the general content of the enclosures. (Relay boxes and Interposing Relay Cabinet (IRC) enclosures do not require additional windows)

5. Color: FA enclosures shall be painted red.

6. Provide seismic certification from manufacturers for equipment and enclosures. (Refer to ASCE7-10 section 13.2.2 2.)

7. Provide anchorage calculations and design details for enclosures and panels. (Refer to ASCE7-10 section 13)

2.12 POWER SOURCE

A. Distribution Panel Boards:

1. Power supply shall be 120V single phase out of existing nearby panel boards.

2. Connect to 3-phase 208/120V or 1-phase 240/120V power source.

B. Power Supply Circuit and Breaker:

1. Each FACU and AMP panel must be labeled with the dedicated electrical panel board and circuit breaker.

2. A dedicated circuit branch shall be only used for the fire alarm system.

3. Breaker shall be new even if the existing breaker space for the FA system is utilized.

4. Breaker shall be 120V single phase, 20A, and must match the panel manufacturer's specification.

5. Each breaker for the FA system shall be equipped with a breaker locking device (according NFPA 72, Section 10.6.5.4).

6. Contractor shall verify exact breaker space depending on panel condition and spare availability.

7. Each circuit must be labeled with red placard "FIRE ALARM SYSTEM" (according NFPA 72, Section 10.6.5.2.2).

8. Conduit shall be minimum 3/4 inch.

9. Provide type and spacing of the fasteners specified/designed for installation of fire alarm devices and conduit installation so that it is within the exception limit of seismic requirements (Refer to ASCE7-10 section 13.4.5.).

2.13 FACTORY TEST

A. Perform final checkouts and test. Ship panels only after required factory tests are performed and required modifications or corrections are made. A factory certificate of inspection is required before shipment and shall accompany the shipping documents.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install initiating devices, control units, audible signals, connections to equipment provided under other sections and related work following equipment manufacturers' requirements for a complete and properly functioning system that will perform specified functions.

B. Interface and Coordination: Indicated diagrams and details show the general location and arrangement of equipment, conduit, wiring, and devices. Provide outlets, control and detection devices, and equipment properly located and readily accessible. Control and detection devices, equipment, and outlets shall be located to avoid interference with mechanical, architectural, and structural features.

C. Control and other panels shall be mounted with sufficient clearance for observation and testing. Fire alarm junction boxes shall be clearly marked for distinct identification.

D. Wiring Methods:

1. Wiring shall be installed in a continuous GRS conduit system. Conduits shall be concealed.

2. Prepare and submit a fire alarm riser diagram indicating type and quantity of devices and size and quantity of conductors and conduits.

3. No wiring other than that directly associated with fire alarm detection, alarm, or auxiliary functions shall be permitted in fire alarm conduits. Wiring splices shall be avoided to the extent possible and if needed, they shall be made only in junction boxes and shall be connected with crimp-type connectors. Wire nut type connections are not acceptable.

4. Transposing or changing color-coding of wires will not be permitted. Conductors in conduit containing more than one wire shall be labeled on each end with wire markers conforming to the requirements of Specifications Section 26 05 24, Low Voltage Wires and Cables. Conductors in cabinets shall be carefully formed and harnessed so that each drops off directly opposite to its terminal. Cabinet terminals shall be numbered and coded. Controls and function switches shall be clearly labeled on equipment panels.

5. Wiring shall be checked and tested to ensure that there are no grounds, opens, or shorts. The minimum allowable resistance between any two conductors or between conductors and ground is 10 Megaohm as checked by a Megger after conduit, conductors, and detector bases have been installed, but before the detector devices are plugged into the bases or end-of-line devices installed.

6. Conduits entering or leaving the terminal cabinets and junction boxes shall be numbered in a logical and consecutive manner. A number shall be used only once.

7. Conductors shall be tagged, labeled, and color-coded. Color-coding shall be by wire insulation, not taping or banding. The numbering and color-coding shall be continuous for each circuit wire.

8. Wire shall be numbered at each connection, termination, and junction point. Wire numbering tags shall be professionally manufactured wire-markers. Each group of wires shall be tagged with its destination at each panel, terminal box, or junction box.

E. Fire alarm circuits in conduit shall be installed in dedicated raceways and shall not be mixed with any other raceway systems of any Class wiring.

F. Provide conduit and properly looped wiring necessary for the total operational system. Conduit size and wire quantity, size, and type shall be suitable for the equipment supplied and conform to equipment Suppliers' requirements. No wiring other than fire alarm circuits shall be permitted in the fire alarm system conduits; 120V circuits shall be in separate fire alarm conduits.

G. End-of-line devices, for either initiating or indicating/notification appliance circuits, shall be mounted in accordance with the manufacturer’s requirements.

H. Automatic detector and occupant notification appliance installations shall conform to NFPA 72.

I. Make conduit and wiring connections to initiating devices, indicating/notification appliances, door release devices, sprinkler flow switches, sprinkler valve tamper switches, and duct smoke detectors.

J. Solid conductors terminated at screwed connections of any type shall be formed about the screw shank in a clockwise direction. Stranded conductors shall be terminated with a pressure-applied lug connector, applied with a tool approved for the use by the lug connector manufacturer and the Engineer.

K. Wiring shall be checked and tested to ensure that there are no grounds, opens, or shorts.

L. Install wiring in accordance with the California Electrical Code, NFPA 72, and Chapter 12 of NFPA 130. Pull conductors to necessary and appropriate devices and appliances.

M. Provide necessary connections and terminations. Field and FACU wiring shall be terminated in terminal cabinets or on field devices/appliances. Connections shall be made on terminals.

N. Provide initial system addressing. Use the District’s room numbers or names for annunciation.

O. The FACU shall be programmed to identify the specific initiating device address or number; location or room number; brief description of room or area; device type; floor level; and status for initiating devices and must match the label on the device.

P. Notify the Engineer at least 30 Days prior to the cutover period when the existing fire alarm system is taken offline, and the new fire alarm system is made operational.

Q. The existing fire alarm system shall remain in operation for the duration of the Work. If any portion of the existing fire alarm system is taken offline, then the Contractor must notify the District and fire watch must be provided until full operation of the fire alarm system is restored.

R. During the cutover period, if the District is unable to provide fire watch, the Contractor shall ensure that public safety is maintained by providing one or more fire watch personnel, as required and approved by the Engineer. Fire watches shall be provided with not less than one approved means for notification of the fire department and their only duty shall be to perform constant patrols of the protected premises and keep watch for fires. Fire watch personnel shall comply with the following:

1. Fire watch personnel shall remain on duty while places requiring a fire watch are open to the public, or when an activity requiring a fire watch is being conducted.

2. On-duty fire watch personnel shall have the following responsibilities:

   a. Identifying and controlling fire hazards, detecting early signs of unwanted fire, raising an alarm of fire and notifying the fire department.

   b. Keep diligent watch for fires, obstructions to means of egress and other hazards.

   c. Take prompt measures for remediation of hazards and extinguishment of fires that occur.

   d. Take prompt measures to assist in the evacuation of the public from the structures.

3.02 FIELD QUALITY CONTROL

A. Provide the testing program, qualified technical personnel, tools, test equipment, and other items required to perform the tests.

B. Furnish written notice as to when installed equipment will be tested so that the Engineer and AHJ can be present to witness the tests. A minimum of 30 Days prior notice of a proposed test shall be provided.

C. At the Contractor’s option, a representative of the equipment manufacturer may be present to witness the tests and verify the results.

D. Tests shall not alter the Contractor’s guaranty of the equipment. Replace and retest work and materials found to be not in compliance with Specification requirements.

E. Maintain test data sheets showing the results of tests performed. Provide data sheets listing the acceptable or specified test limits and the values actually measured. Furnish one set to the Engineer. Retain one set.

F. Provide data sheets showing the test set-up, the equipment used, the names of persons performing the test, the names of witnesses, the date, the location, and the serial number of the equipment under test. The test data sheets will be reviewed by the Engineer and accepted as submitted, or additional tests may be required. If additional tests are required because initial test results do not comply with these Specifications, the retesting shall be documented and submitted as before.

G. Perform inspection of control panel as follows:

1. The inspection shall first cover a physical check of panels in reference to the following items:

   a. Proper model numbers.

   b. Arrangement of instruments per Shop Drawings on panel front.

   c. Arrangement of back-mounted accessories for proper clearance, operation, and maintenance.

   d. Finish of panel.

   e. Tagging of wiring.

2. A test as per Article 3.09 and checkout report shall be prepared by the technician and submitted in triplicate, one copy of that shall be registered with the equipment manufacturer. Report shall include, but not be limited to:

   a. A complete list of equipment installed and wired.

   b. Indication that equipment is properly installed and functions and conforms with this Contract Specification.

   c. Tests of individual zones as applicable.

   d. Serial numbers, locations by zone, and model number for each installed detector.

   e. Voltage (sensitivity) settings for each detector as measured in place with air conditioning system operating.

   f. Response time on thermostats, flow switches, and flame detectors (if used).

   g. Technician’s name, certificate number, and date.

   h. Perform sequence of operations tests as shown in Attachment A.

3. After completion of the physical inspection, perform circuit checkouts as required to verify the correct operation of the system.

H. Field Tests

1. The Contractor shall perform electrical and mechanical tests required by NFPA 72, and the equipment manufacturer’s installation procedures. A sample functional test procedure is shown in Attachment B.

2. Pre-testing: The system shall be pre-tested prior to final Acceptance testing. All points shall be tested from point of initiation to the final point or points of annunciation. Circuits shall be tested for continuity and ability to transmit the required signal correctly to the FACP. Problems due to wrong wire type, wire twist, impedance, mismatches, noise filtering, or shielding shall be corrected during pre-testing and prior to any final Acceptance tests. Pre-testing shall include every device in the system. Coordinate with other trades as necessary for testing. Provide the following tests and procedures:

    a. Sprinkler Flow Switches: Record time delay from water flow to alarm and adjust as necessary for 30 to 50 seconds delay.

    b. Valve Tamper Switches: Verify “trouble” signal is received on closing of each valve.

    c. Smoke Detectors: Test with actual or approved artificial smoke. Verify that reset does not occur when devices are cleared of smoke. Verify supervisory circuit function.

    d. Elevator Recall: Verify that elevators recall to designated floor.

    e. Escalator: Verify that power to the driving machine motor is interrupted and brakes apply upon station fire alarm signal.

    f. Central Notification: Verify that one set of conductors in the terminal cabinet becomes a short circuit on any “trouble” condition and that the other set becomes a short circuit on any alarm condition. Verify that the conductor groups are labeled properly.

3. The Contractor shall measure and adjust each of the detectors to the maximum stable sensitivity setting. This shall be performed at the operational location of the unit and under normal operational environmental conditions in the area. Bench settings are not acceptable.

4. Test splice points back to previous splice or terminal points before encapsulant is placed around the splice point.

5. Check electrical instruments and each electrical circuit for continuity either by checking entire “loops” if within panel or by simulating field conditions or operations. This test shall include instruments, alarms, relays, and pressure switches that are part of the panel circuits. When full simulation is not possible or practicable, wires shall be given a point-to-point continuity check.

3.03 FIRE ALARM NAMEPLATES

A. Identify fire alarm equipment devices so that the address may be visible from the floor.

3.04 PROGRAMMING

A. The Contractor shall use a factory certified technician for all programming.

B. The District's room numbers or names provided by the Engineer for annunciation shall be used. The Contractor shall update the Construction Drawings to reflect the addresses used.

3.05 JOB CONDITIONS

A. Coordinate Work schedule and material deliveries with the Engineer.

B. Minimize impairments of existing fire protection system and coordinate any proposed shutdown with the Engineer. Restore existing fire protection systems removed from service as part of this Work at the end of each working day.

C. The Work performed occurs within existing buildings. Equipment and material furnished and installed from the Work shall be coordinated with existing space constraints. Fabricate equipment and material such that complete systems may be broken down into sections suitable for passage through existing passageways without modification to the building unless other arrangements are made with the Engineer to provide access.

3.06 PENETRATIONS

A. The Contractor shall be responsible for openings and penetrations required.

B. Provide penetrations of rated assemblies with through penetration fire stop systems with T ratings equal to those of the assembly penetrated.

3.07 PAINTING

A. Exposed conduit shall be painted to match the surrounding wall or ceiling surface. Clean exposed surfaces of oil, dirt, and other debris to the satisfaction of the Engineer prior to painting. Paint samples shall be approved by the Engineer prior to application.

3.08 DEMONSTRATION AND TRAINING

A. General:

1. Prior to Final Inspection and Acceptance, instruct and train the District's designated operating and maintenance (O&M) personnel in the operation, start-up and shut-down, adjustment, troubleshooting, servicing, and preventive maintenance of equipment and systems.

2. Explain to the District's O&M personnel, in full and to their complete understanding, procedures necessary to operate and maintain equipment and systems on a continuing basis.

3. Provide training manuals and other instructional materials and teaching aids as required to properly perform the required instruction and training.

4. Review the contents of O&M manuals specified in Section 01 78 23, Operation and Maintenance Data, with the District's O&M personnel in full detail to explain all aspects of the manuals and the operation and maintenance of equipment and systems.

5. Provide classroom and on-site instruction as most appropriate for the equipment or system.

6. Training programs shall be provided by manufacturer certified personnel.

7. Operation and maintenance manuals are specified in Section 01 78 23, Operation and Maintenance Data, and may be used for student training manuals upon approval.

8. Various specific and detailed requirements for instruction and training of the District personnel are specified in this Section, and in Sections 01 35 14, Operating System Interface and 01 35 24, Construction Safety.

B. Target Audience:

1. Station Agents: Must be able to reset alarms. Training to be conducted via train-the-trainer sessions.

2. Electricians: Training shall include basic familiarization and preventive maintenance procedures: removing, cleaning, replacing and testing components, disabling and enabling components through programming and interpreting the signaling output.

3. Fire Alarm Technicians/Engineers: Must be factory certified. Training shall include how to install, operate, start-up and shut-down, adjust, maintain, inspect, troubleshoot, test and modify equipment and systems. Training must include procedures necessary for preventive maintenance on the equipment and systems on a continuing basis. Must be able to program the Fire Alarm Control Unit (FACU). Programming tasks include, but are not limited to, deleting a device or zone, recognizing a substitute or replacement device.

4. Number of participants to train are as follows:

   a. Station Agent Trainers: 2

   b. Electricians: 20

   c. Fire Alarm Technicians/Engineers: 6

C. Classroom Sessions:

1. The Contractor shall provide instruction and training sessions in the operation and maintenance of equipment and systems for the District O&M personnel prior to Acceptance by the Engineer of the affected work.

2. Minimum class lengths are as follows:

    a. Station Agent Train the Trainer: 4 hours

    b. Electricians: 4 hours

    c. Fire Alarm Technicians/Engineers: 40 hours

3. Contractor shall provide a detailed instructor guide for the Station Agent and Electrician courses. The instructor guide is a written record of the facts and details taught in the training course. Instructor guide shall include a course outline broken down by topics with a description of key points covered in each topic, the method of delivery, details for conducting hands-on activities and any actions required to configure and prepare training equipment/training aids.

4. Training sessions shall be conducted by representatives of the various equipment and product manufacturers and the Subcontractors who are involved in the installation and acceptance testing of the affected equipment and systems. Training sessions shall enable a qualified service technician to troubleshoot and sustain the equipment and systems.

5. The Engineer will provide a classroom facility for such instruction and training sessions as required for Station Agent Train the Trainer and Electricians.

6. For the electrician course, a demonstration class shall be conducted to demonstrate compliance with this technical specification section and for approval of the Engineer.

    a. The approved instructor guides, training materials and training aids shall be used in the demonstration class.

    b. The demonstration shall be presented to an evaluation team composed for the District personnel from the group to be trained, including Employee Development Specialists, Supervisors, and Foreworkers.

    c. The evaluation team shall prepare a list of nonconformances, and recommend either acceptance, acceptance with changes, or rejection of the training demonstration.

    d. The evaluation team may recommend that all (when rejected) or a portion (when accepted with changes) of the training demonstration be repeated.

7. The Contractor shall schedule the training sessions through the Engineer at a time convenient to the District.

    a. Training classes for Electricians required on shifts as follows:

        1) 2 classes on day shift

        2) 2 classes on swing shift

        3) 1 class on graveyard shift

    b. The Contractor shall notify the Engineer of the proposed Station Agent and Electrician training sessions at least 30 Days before the dates the training will be held.

c. The Contractor shall notify the Engineer of the proposed training session dates for the Fire Alarm Technician/Engineer course at least six weeks prior to those dates.

D. On-Site and Hands-on Sessions:

1. Provide on-site, hands-on training sessions as required to demonstrate actual operating and maintenance procedures on the equipment. Hands-on training shall provide District personnel with actual operating and maintenance experience. Hands on sessions will enable each student to practice on the equipment. Demonstration by the instructor is not adequate.

2. Provide equipment and training aids to enable hands-on training in a location other than where the equipment is installed.

3. Installed equipment must be sufficiently tested to confirm it operates as expected before training is conducted and to enable completion of all hands-on activities and maintenance procedures.

4. Maximum class size for hands-on training is four (4).

E. Train the Trainer

1. Contractor shall deliver two (2) classes as designed for the EDS (trainers) responsible for training Station Agents.

2. Contractor shall review the instructor guide with the EDS after delivery of the course.

3. Contractor shall walk through how to configure training equipment/training aids in accordance with the instructor guide.

4. Contactor shall observe a minimum of one delivery per EDS trained via Train the Trainer session to confirm course is delivered as designed and accurate information provided.

5. Contractor shall be available to answer questions until all staff are trained. Questions shall be answered within 48 hours (two calendar days) of submission.

F. Videotaping Rights: The Engineer shall have the right to videotape of all training sessions presented by the Contractor. The Engineer shall also have the right to use these videotapes for future District conducted training courses

3.09 TRAINING MANUALS AND TRAINING AIDS

A. The Contractor shall provide instructor guides, student training manuals and any other materials or training aids to supplement the O&M Manuals specified in Section 01 78 23, Operation and Maintenance Data, and submit them to the Engineer for review and approval at least 60 Days before the scheduled start of training sessions. Student training manuals shall be prepared specifically for use as

training aids. All materials must be approved before the start of training, including applicable demonstration class.

B. Operation and Maintenance Manuals are specified in Section 01 78 23, Operation and Maintenance Data. O&M manuals may be used for student training manuals with approval.

C. Provide each training-session participant with one copy of pertinent training manuals at the start of training sessions. Provide the Engineer with electronic copies of all instructor guides, student training manuals, and any other materials.

D. Upon completion of each training session or course of instruction, instructor's manuals, O&M manuals, training manuals, training aids and special tools shall become the property of the District. Provide the Engineer with all revisions to the training manuals throughout the Contract and Guaranty periods.

E. The District reserves the right to copy all training manuals and training aids for use in District-conducted training courses.

F. The Contractor shall be responsible in providing all tools, equipment, training aids, and other materials required for the training of District personnel. The number of special tools and other training equipment shall be adequate for the number of participants attending the training sessions.

G. The Contractor shall provide copies of the program user software and licenses for each individual participating in the Fire Alarm Technicians/Engineers training.

3.10 SYSTEM ACCEPTANCE

A. Procedure for the Acceptance tests shall be submitted for the Engineer's approval. Tests shall be performed in the presence of the Engineer.

B. The completed system shall be tested to ensure that it is operating properly. The testing shall consist of exposing the installed detection units to the standard test per requirements of NFPA 72.

C. Acceptance of the system shall require a demonstration of the operation and stability performance of the system. This shall be adequately demonstrated if the system operates for a ninety (90) day period without any unwarranted alarms. Should an unwarranted alarm(s) occur, the Contractor shall readjust or replace the detector(s) and begin another ninety (90) day test period.

D. As required by the Engineer, the Contractor shall recheck the detectors using the installation standard test after each readjustment or replacement of detectors. This test shall not start until the Engineer has obtained beneficial use of the building under test.

E. If the requirements of the above paragraphs are not completed within one (1) year after commencing the tests described therein, the Contractor shall replace the system, and the process shall be repeated until acceptance of the equipment.

F. Perform Sequence of Operation test procedures as shown in Attachment A.

END OF SECTION 28 31 00

ATTACHMENT A TO SECTION 28 31 00

SEQUENCE OF OPERATION

EVENT \ RESPONSE	ANNUNCIATE EVENT AT THE FACU	FIRE SIGNAL TO BART CENTRAL VIA SCADA	TROUBLE SIGNAL TO BART CENTRAL VIA SCADA	SUPERVISORY SIGNAL TO BART CENTRAL VIA SCADA	OPERATE NOTIFICATION APPLIANCES	OPERATE ESCALATOR SHUT DOWN RELAYS	OPEN FARE GATES VIA BART SCADA	SHUT DOWN SF-1 OR SF-2 AS APPROPRIATE	SHUT DOWN TRAIN CONTROL HVAC SUPPLY FAN	CLOSE FSD AT TRAIN CONTROL SUPPLY HVAC FAN	RECALL ELEVATOR TO PRIMARY FLOOR	RECALL ELEVATOR TO SECONDARY FLOOR	OPERATE ELEVATOR POWER SHUNT TRIP	
MANUAL FIRE ALARM PULL STATION	●	●			●	●	●							
GENERAL AREA HEAT DETECTOR	●	●			●	●	●							
GENERAL AREA SMOKE DETECTOR	●	●			●	●	●							
SF-1/SF-2 DUCT SMOKE DETECTOR	●			●				●						
TRAIN CONTROL HVAC SUPPLY FAN SMOKE DETECTOR	●	●							●					
SMOKE DETECTOR AIR INTAKE TRAIN CONTROL FAN	●	●			●	●	●		●	●				
ELEVATOR MACHINERY ROOM HEAT DETECTOR	●	●			●	●	●				●		●	
ELEVATOR MACHINERY ROOM SMOKE DETECTOR	●	●			●	●	●				●			
ELEVATOR LOBBY SMOKE DETECTOR (CONCOURSE)	●	●			●	●	●					●		
ELEVATOR LOBBY SMOKE DETECTOR (PLATFORMS)	●	●			●	●	●				●			
FIRE SPRINKLER WATERFLOW SWITCH	●	●			●	●	●							
FIRE SPRINKLER VALVE SUPERVISORY SWITCH	●			●										
FIRE ALARM CONTROL UNIT FAULT	●		●											
NAC POWER SUPPLY FAULT	●		●											
NAC AMPLIFIER FAULT	●		●											
CIRCUIT FAULT	●		●											

ATTACHMENT B TO SECTION 28 31 00

FIRE ALARM /SCADA SYSTEM INTERFACE

FUNCTIONAL TEST

1.01 TEST OBJECTIVES

A. To verify that the fire alarm/SCADA interface performs correctly in response to various fire alarm conditions

B. Repeat the tests for each station and record the results in the test report.

1.02 TEST PROCEDURE

Step #	Description
1.	Activate a “manual pull station”. Verify that the alarm is reported on the SAB control panel and at OCC but do not acknowledge the alarm. Verify that the fare gates open. Verify that 15 seconds later that the message “Escalator about to be stopped” is announced over the speaker system. Verify that the alarm is broadcast. After one minute, acknowledge the alarm and verify that the notification appliances stop. Repeat step 1 and acknowledge the alarm immediately. Verify that the message is not broadcast over the speaker system and that the alarm is not initiated.

SUMMARY TEST REPORT CHECKLIST – FIRE DETECTION AND ALARM SYSTEM*

Test #	Station 1	Station 2	Station 3	…	Comments
1.					
2.					
3.					
4.					

Enter a check mark if acceptable; enter N if unacceptable.

*Contractor shall provide the list of tests that need to be performed.

Tested by: _____ Date: _____

Witness initials: _____; _____; _____

END OF ATTACHMENTS TO SECTION 28 31 00

SECTION 28 41 29

CLOSED CIRCUIT TELEVISION SYSTEM

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Functional requirements.

B. Equipment

1.02 RELATED SECTIONS

A. Section 01 33 00, Submittal Procedures, and Contract Specifications

B. Section 01 33 23, Shop Drawings, Product Data and Samples

C. Section 01 45 24, Testing Program Requirements

D. Section 20 70 26, Common Materials and Methods for Electrical Systems

E. Section 20 70 23, Electronic Circuits, Wires, and Cables

F. Section 20 50 13, Raceways for Facility Services

G. Section 20 72 25, General Requirements for Factory and Field

1.03 MEASUREMENT AND PAYMENT

A. Measurement: The Closed Circuit Television (CCTV) system, as specified herein, will be measured for payment as a lump-sum unit acceptably installed and tested for compliance.

B. Payment: The CCTV system will be paid for at the Contract lump-sum price for the CCTV system or as part of the lump sum price for Communications Work, as determined by the lump sum measurement specified above, as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. California Occupational Safety and Health Standards (OSHA)

B. Electronic Industries Association (EIA)/Telecommunications Industry Association (TIA):

1. Bulletin #1 CCTV Definitions

2. EIA-310D 19-inch Rack Standard

3. EIA/TIA-568 Commercial Building Telecommunications Cabling Standard

4. EIA-632 Electronics Industries Alliance (EIA) Standard: Processes for Engineering a System

5. EIA-649 Standard for Configuration Management

6. EIA-836 Configuration Management Data Exchange and Interoperability

C. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE Std. 1220-1998: IEEE Standard for Application and Management of the Systems Engineering Process

D. International Electrotechnical Commission (IEC) or International Organization for Standardization (ISO):

1. IEC/ISO 13818: Information Technology – Generic Coding of Moving Pictures and Associated Audio Information

E. Manufacturing Method (MM):

1. MM-33A Process Control Specification for Paint Application

2. MM-42 Process Control Specification of Chromate Conversion Coating

F. National Fire Protection Association (NFPA):

1. NFPA 70 National Electrical Code

G. Underwriters Laboratories (UL):

1. UL 2044 Standard for Commercial Closed Circuit Television Equipment

2. UL 2391 Equipment with Remote Feeding Telecommunication circuits Intended for Backwards Compatibility in Legacy Telecommunication Equipment

3. UL 3044 Standard for Surveillance Closed Circuit Television Equipment

1.05 SUBMITTALS

A. Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Submit the following:

1. Systems design presented in functional block diagrams and system electrical/electronic signal flow diagrams indicating signal levels and impedance values.

2. Product verification list with pictorial view and full performance specifications.

3. Detailed installation drawings to include installation configuration and methods of installation.

4. List of proposed lenses for camera installations. Calculations of coverage shall be provided for all cameras.

5. Operation and maintenance data to include operation instruction, detailed parts list, cable and wire lists, circuit diagrams, maintenance, alignment, and troubleshooting procedures.

1.06 QUALITY CONTROL

A. Products shall be manufactured by firms regularly engaged in manufacturing products described in this section.

B. Field testing shall be performed by persons having five or more years of relevant testing experience.

1.07 SYSTEM DESCRIPTION

A. Furnish a CCTV system in the passenger stations for video surveillance of areas in the station, and adjoining parking structure, pocket track, tail tracks, trans-bay tube, and vent structures as applicable, and as indicated.

B. Provide all interfaces with other systems in the station and in the BART network operating system, as specified and indicated, to provide a completely integrated operating system.

1.08 FUNCTIONAL REQUIREMENTS

A. General:

1. An average of 100 IP-based digital cameras shall be required per station, excluding parking structures.

2. Video shall be available in IEC-13818 encoding formats of Advanced Video coding (H.264), High Efficiency Video Coding (H.265), and MJPEG.

3. There shall be no recording or storing of images at any stations.

4. The BART video recovery unit shall have supervisory control of the video management system (VMS) and be the primary location for displaying and exporting video. Police Integrated Security Response Center (ISRC), also known as the BART Police Dispatch Center (PDC), shall have video clients for viewing and controlling cameras. The Operations Control Center (OCC) shall have two computer workstations and one large display in order to access and view video from the CCTV network.

5. Video shall be stored in a storage area network (SAN) at the Lake Merritt facility. Stored video shall be limited to the most recent seven days.

B. The CCTV system shall provide for video surveillance of areas in passenger stations, parking structures, pocket track, and end-of-line tail tracks as applicable.

1. Passenger Station Areas:

a. Platform and Mezzanine Areas. Cameras shall be furnished for viewing platform and mezzanine areas including rescue assistance areas and elevator entrances, as indicated. Cameras focused on elevator entrances shall be equipped with lenses having adequate coverage to allow viewing from the Station Agents Booth of patrons using the elevators. Cameras on platforms shall be oriented to allow viewing from the Station Agents Booth of the platform edges for the length of the platforms.

2. Automatic Fare Collection Equipment:

a. Pan, tilt, zoom (PTZ) cameras shall be furnished to monitor automatic fare collection (AFC) equipment including the ticket vending machines, add fare machines, and bill-to-bill changers. “Door open” alarms provided with the fare collection equipment shall cause cameras to move to a position to monitor the alarmed machine. Automatic recording shall be initiated upon activation of the “door open” indication.

b. AFC equipment with “door-open” indications shall be monitored in order of priority.

c. When an AFC door is reclosed, the associated camera shall return to the normal preset position.

3. Pocket Track and End-of-Line Tail Tracks:

a. PTZ cameras shall be furnished for viewing areas in the pocket and end-of-line tracks, as indicated.

4. Parking Structures. Cameras shall be provided for viewing internal area and entry area of elevators and stairwell areas. Fixed cameras shall be furnished for viewing as directed by BART Police and BART Engineering.

C. Interfaces of the CCTV system with other communication subsystems shall be as follows:

1. “Door open” indications of ticket vending machines, add fare machines, bill-to-bill changers, and parking machines for automatic positioning of video cameras shall be monitored by the supervisory control and data acquisition (SCADA) system. The SCADA system shall retransmit a contact closure to the associated PTZ camera to set the camera to a preset viewing position.

2. Method of connection to the IP-based network designated for transmission of video images shall be determined by BART Engineering.

PART 2 – PRODUCTS

2.01 EQUIPMENT REQUIREMENTS

A. General:

1. CCTV equipment providing the same functions shall be uniform and have the same type and model supplied by a single manufacturer.

2. All necessary accessories, devices, wires, and cables shall be furnished for proper interconnection of the equipment specified herein to provide a completely integrated and operational CCTV system.

3. CCTV monitoring and control equipment, as indicated, herein shall be furnished to allow monitoring of selected video images in the Station Agent's Booth, Emergency Management Panel Room, and the Supervisor's Booth at end-of-line stations.

4. CCTV equipment in the Train Control Room shall be designed for mounting in standard 19-inch rack per EIA RS-310D.

5. CCTV network and storage shall support all installed IP-based cameras per station streaming data at 5Mbits/sec for 1080p cameras and 12Mbits/sec for 4K cameras.

B. Cameras:

1. Cameras shall be Designated Matching Products; refer to the Designated Matching Products (DMP) List.

C. Camera Lenses:

1. Lenses shall be auto-iris lenses directly interchangeable without electrical or mechanical modifications or adaptations. Each lens shall have a neutral density spot filter. Lenses shall be capable of mounting in a sealed environmental housing.

2. PTZ cameras shall have a minimum of 20X optical zoom and 10X digital zoom.

D. Camera Housings:

1. Cameras shall meet the Ingress Protection (IP) rating of IP66 and International Electrotechnical Commission (IEC) Standard 62262 for Impact Protection (IK) Code IK10.

2. Cameras installed outdoors shall be furnished with environmental housings. The housings shall be equipped with heater kit, blower kit, and power supply. Housings exposed to direct sunlight at any time of day shall be equipped with a sun shield.

3. Cameras monitoring AFC equipment and those installed in elevators shall use a security housing with the following characteristics:

    a. High security, vandal resistant, and corner mount type. The enclosure shall be tamper-proof with tamper-proof design subject to District approval.

    b. The housing shall be compatible with the camera in the elevator.

    c. Security enclosures shall be domed housings suitable for outdoor service. The housings exterior surface shall be tinted to conceal the interior camera from view.

    d. The view from the housing shall encompass a 360-degree horizontal view and 45-degree vertical view. The vertical view shall extend from five degrees above the horizontal to 40 degrees below the horizontal.

    e. Security enclosures shall be tamper-proof to prevent the general public from accessing the interior of the enclosure.

    f. Tamper-proof designs shall be subject to District approval.

E. Camera Mountings:

1. Wall or Ceiling Mount: The camera mount unit shall be designed to support loads of up to 125 lbs. at the point of the camera attachment at an attitude of 90 degrees perpendicular to a wall surface. Each mount assembly shall be equipped with an adjustable head adapter that shall allow 360 degree horizontal and $\pm$ 90 degree vertical plane adjustment.

2. Pole Mount: Adapters shall be provided for placing standard wall or ceiling mount units on camera equipped poles. All parts shall be protected from corrosion.

3. The housing mounts for the elevator cab cameras shall be tamper-proof with tamper-proof design subject to District approval. The mounts shall be heavy duty that shall safely support a load of 120 pounds minimum.

F. Monitors:

1. Monitors shall be as specified in the Contract.

G. Video Servers:

1. Video servers shall meet the minimum specified hardware requirements of the VMS software manufacturer.

H. Video Storage:

1. Video shall be stored at centralized storage area network (SAN) storage facility designated by the District.

2. Systems shall utilize open application programming interfaces (APIs) and open software development kits (SDKs).

3. Storage capacity shall be sufficient for 7 days at full frame rate.

I. Control Panel: Cameras shall be controlled through the video manager software that is furnished by the District.

J. PTZ cameras shall have a minimum of 16 user-defined presets with a repeatable accuracy of +/- 0.2 degrees. This shall include PTZ positioning, and camera focus.

K. A contact closure from the SCADA system signifying a “door open” indication of a vending or add fare machine shall cause the appropriate camera to point and focus to the front of the pre-designated alarmed machine.

L. Wires and cables between equipment assemblies and termination points within each equipment enclosure shall be furnished. Wires and cables shall be listed as being resistant to the spread of fire in accordance with the National Electric Code (NEC), and shall be rated at 300 volts, minimum. Wires and cables servicing remote camera units shall be waterproof.

1. Video Cables: Video cables shall be as specified in Section 20 70 23, Electronic Circuits, Wires, and Cables.

2. Control Cables: Control cables shall be multi-conductor AWG No. 18 stranded copper conductors with braided shields.

3. Power Cables: Minimum conductor size for power circuits shall be AWG No. 14.

M. Fiber-optic transceivers for transmission of video signals from tail-track cameras shall be the small form-factor-pluggable (SFP) type. Fiber availability will be determined by BART Engineering.

1. Where there is sufficient fiber:

   a. Two fibers, one for transmit and one for receive, will be allocated per transceiver.

   b. SFP style transceivers shall be used.

   c. LC connectors shall be used.

   d. SFP type (SX, LX, or ZX) will be designated on all drawings and documentation.

2. Where there is not sufficient fiber:

   a. One fiber shall be used for both transmit and receive.

   b. The transceivers shall meet the following characteristics:

      1) Compatible with 50/125 low loss multi-mode glass fiber.

      2) Nominal operating wavelength of 850/1300 nm.

      3) Range up to three miles.

      4) Category 6 UTP to fiber optic converters.

3. Multimode fiber-optic cables for the tail-track cameras shall be as specified in Section 20 70 23, Electronic Circuits, Wires, and Cables. LC type connectors with strain relief and breakout kits shall be furnished.

N. All equipment shall be mountable in a standard 19-inch rack per EIA RS-310D.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Cameras shall be mounted in locations shown on the Contract drawings.

B. Cameras accessible to the public shall be concealed or placed in protective, tamper-proof environmental enclosures and surface mounted beyond a person's normal reach plus an additional three feet.

C. Cameras shall be located so that their FOV is not restricted by other station installations such as walls, ceilings, columns, signs, and luminaries. Plans demonstrating the unobstructed FOV of each camera shall be submitted for District review.

D. Cameras shall be located so that they never directly view the sun. The FOV of cameras shall be adequately illuminated either by natural light or by luminaries. Within the FOV, particular care shall be taken to avoid extremes of light and shadow.

E. Cameras and other video surveillance equipment installed in locations accessible to the public shall be mounted using tamper-proof mounting hardware.

F. Camera video signal cables between each camera and the associated field concentrator shall be routed as shown without any splices. All cables shall be installed complying with the requirements of Contract Specification Section 20 70 26, Common Materials and Methods for Electrical Systems, Contract Specification Section 20 70 23, Electronic Circuits, Wires, and Cables, and Contract Specification Section 20 50 13, Raceways for Facility Services.

G. Field concentrators and their associated power distribution and PTZ camera power supply panels shall be installed as shown in Contract drawings.

H. Fiber optic cables between the field concentrators and the fiber distribution cabinet in each Train Control Room (TCR) shall be installed and terminated as shown in Contract drawings.

3.02 TESTING

A. Factory and field testing shall be performed in accordance with Contract Specification Section 01 45 24, Testing Program requirements.

B. Factory Tests: Perform a factory test consisting of one field concentrator, and one PTZ camera power supply be performed to demonstrate correct operation as shown in Contract Drawings and Specifications.

C. Field Tests: Complete the following:

1. Perform the following camera cable tests as indicated following the approved test plan. Furnish all equipment, appliances, and labor necessary to test the installed camera cable between the camera assembly and the field concentrator. Perform the following tests before any connections are made:

    a. Perform testing in accordance with the latest EIA/TIA-568 standard for all Category-type cables installed. Camera cable shall not exhibit any discontinuities such as opens, shorts, crimps, or defects.

    b. Perform continuity tests on the camera cables using a meter having a minimum input resistance of 20,000 ohms per volt. Show that each conductor has a resistance of not more than 16 ohms per 1000 feet of conductor run.

    c. Measure the insulation resistance between the conductors and between each conductor, ground, and shielding using a megger meter. Perform all resistance testing after final termination and cable installation, but prior to connection of any electronics or field devices.

    d. Replace any cable that fails to meet these parameters, or if any testing reveals defects in the cable. Retest new cable as specified above.

    e. Furnish all test equipment.

2. Perform the following local field operations tests on site in accordance with the approved field test plan. Demonstrate the following after the camera controller assemblies, other camera hardware, field concentrators, power supplies and connecting cabling have been installed:

    a. Verify physical construction has been completed in accordance with the plans and specifications.

    b. Inspect quality and tightness of ground and surge protector connections.

    c. Check power supply voltages and output.

    d. Connect devices to power source.

    e. Verify installation of specified cables and connections between camera, pan/tilt unit, and camera control receiver.

END OF SECTION 28 41 29

SECTION 31 00 00

EARTHWORK

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Staking and grades.

B. Existing utilities.

C. Earthwork general requirements.

D. Subsurface extraction.

E. Rough grading and filling.

F. Excavation.

G. Embankment construction.

H. Subgrade preparation.

I. Foundation preparation.

J. Subgrade filling/raising grade.

K. Compaction.

L. Backfilling.

M. Finish grading.

N. Field quality control.

1.02 RELATED SECTIONS

A. Dewatering is specified in Section 31 23 19, Dewatering.

B. Shoring and underpinning are specified in Section 31 40 00, Shoring and Underpinning.

C. Excavation support systems are specified in Section 31 50 00, Excavation Support and Protection.

D. Aggregate sub base is specified in Section 32 11 17, Aggregate Sub base Courses.

E. Aggregate base course is specified in Section 32 11 23, Aggregate Base Courses.

F. Aggregate drainage fill is specified in Section 32 11 24, Aggregate Drainage Layer.

G. Excavating and backfilling for subsurface drainage and utilities are specified in Section 33 05 28, Trenching and Backfilling for Utilities.

H. Drainage and filter aggregates and permeable material for subsurface drainage are specified in Section 33 46 00, Subdrainage.

1.03 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for earthwork will be either by the lump-sum method or by the unit-price method as determined by the listing of the bid items for earthwork indicated in the Bid Schedule of the Bid Form.

B. Lump Sum: If the Bid Schedule indicates a lump sum for earthwork, the lump-sum method of measurement and payment will be in accordance with Section 01 20 00, Price and Payment Procedure, Article 1.03.

C. Unit Prices

1. Measurement Method: If the Bid Schedule indicates unit prices for earthwork, the unit-price method of measurement and payment will be in accordance with the following requirements.

2. Measurement Unit: The following classifications of work will be measured for payment by the cubic yard unless otherwise indicated:

    a. Excavation - Common;

    b. Excavation - Rock;

    c. Structure Excavation;

    d. Structure Backfill;

    e. Fill for Raising Grade;

    f. Pervious Backfill;

    g. Common Embankment;

    h. Select Embankment; and

    i. Subsurface Extraction.

3. Measurement for Payment of Excavations, Fill, Backfill, and Embankment:

    a. Excavations will be measured for payment by the cubic yard, and quantities will be computed, based on the neat lines or pay lines, section profiles, contours, and dimensions indicated on the Contract Drawings.

    b. Fill for raising grade, backfill, embankment, and pervious backfill, including placement and compaction, will be measured by the cubic yard in place, and quantities will be computed, based on the neat lines or pay lines, section profiles, finish grades, and dimensions indicated on the Contract Drawings.

c. The upper limit for payment of excavations shall be the ground surface as it existed prior to the start of construction operations.

d. The upper limit for payment of backfill, when otherwise not indicated in the Contract Documents, shall be the ground line at the time the excavation is made; except the upper limit for fill shall be the finished grade indicated.

e. The lower limits for computing pay quantities of excavation and backfill shall be a plane at the bottom of the completed footings or structures. The lower limit of fill shall be the existing grade at start of construction or the excavated bottom as indicated.

f. Salvaging of topsoil will be classified and measured as Excavation - Common.

4. Measurement for payment of Subsurface Extraction:

a. The volumes of structures, the removal of which is measured and paid for as subsurface extraction, will be deducted from the quantities of excavation computed as herein specified.

b. Subsurface extraction will be measured for payment by the lump sum, cubic yard, linear foot for pipelines, or other appropriate unit as listed in the Bid Schedule of the Bid Form.

c. If no pay item is provided in the Bid Schedule for the removal of a subsurface man-made object, the removal and disposal of such object will be paid for at the Contract unit price applicable to the excavation in which the item is encountered.

d. If the presence of the object is not indicated in the Contract Documents, and its presence could not have been detected by visual inspection, the removal and disposal of the item will be paid for as Differing Site Conditions as specified in the General Conditions, Article GC4.6.

5. Items Not Measured for Payment:

a. Compacting original ground or scarified sub grade will not be measured separately for payment, and all costs in connection therewith will be considered incidental to the material or structure to be placed or constructed on the compacted original ground or sub grade.

b. Sub grade and bearing-foundation preparation will not be measured separately for payment, and all costs in connection therewith will be considered incidental to the material or structure to be placed or constructed on the sub grade or bearing foundation.

c. Re-handling of stockpiled material will not be measured separately for payment, but will be considered incidental to the earthwork to which it pertains.

d. Borrow excavation will not be measured separately for payment, but will be included in the costs for fill and backfill materials.

6. Payment: Payment for earthwork will be made at the Contract unit prices for the computed quantities as determined by the measurement methods specified herein. Payment will be made only for items listed in the Bid Schedule of the Bid Form. All other work will be considered incidental to and included with the Bid Items.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM C131/C131M Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
2. ASTM C136/C136M Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
3. ASTM C535 Standard Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact the Los Angeles Machine
4. ASTM D653 Standard Terminology Related to Soil, Rocks, Rods, and Contained Fluids
5. ASTM D1140 Standard Test Methods for Determining the Amount of Material Finer Than 75-um (No. 200) Sieve in Soils by Washing
6. ASTM D1557 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lb/ft3 (2,700kN-m/m3))
7. ASTM D2216 Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
8. ASTM D2487 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
9. ASTM D2974 Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Materials
10. ASTM D4253 Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table
11. ASTM D4254 Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density
12. ASTM D4318 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

13. ASTM D6913/ D6913M — Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

14. ASTM D6938 — Standard Test Methods for In-place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

B. State of California, Department of Transportation (Caltrans), Standard Test Methods:

1. Calif. Test 217 Method of Test for Sand Equivalent

1.05 DEFINITIONS

A. Earthwork Terminology: Terms used in this Section and not defined herein shall be interpreted in accordance with the definitions given in ASTM D653.

B. Soil Classification: Soil classification is based on the Unified Soil Classification system given in ASTM D2487. Group symbols, when used, conform with the symbols of ASTM D2487.

C. Fill: Soil or soil-rock material placed to raise the subgrade or natural grade of the site.

D. Backfill: Soil or soil-rock material used to backfill excavations and to backfill excavated spaces around foundation walls, building walls, retaining walls, head walls, and abutments.

E. Embankment: Soil or soil-rock material for embankment construction. Embankment construction includes constructing embankments and dikes, including the preparation of the areas upon which they are to be placed; and the construction of temporary surcharge embankment above the grading plane.

F. Borrow: Soil or soil-rock material used for fill, backfill, embankment, or other construction that is excavated from an off-site location and hauled in.

G. Unsuitable Material: Excavated material or material below the natural ground surface in embankment areas or below sub grade elevation in excavated areas, which is unsuitable for its planned use. Unsuitable material is further defined as material determined to be:

1. Incapable of being compacted to specified density using ordinary methods at optimum moisture content; or

2. Too wet to be properly compacted and circumstances prevent suitable drying prior to incorporation into the work; or

3. Otherwise unsuitable for the planned use.

The presence of excessive moisture in a material is not, by itself, sufficient cause for determining that the material is unsuitable. The existence of unsuitable material may be indicated in the Contract Documents or may be determined by the Engineer during the progress of the work.

H. Relative Compaction: The ratio, expressed as a percentage, of the in-place dry density of material as compacted in the field to the maximum dry density of the same material as determined by laboratory test ASTM D1557.

I. Optimum Moisture Content: The water content at which a soil can be compacted to a maximum dry unit weight by a given compactive effort.

J. Relative Density: Mass per unit volume as specified in ASTM D4253 and ASTM D4254, as applicable to the soil and test method employed.

1.06 CLASSIFICATION OF EARTHWORK

A. For specification purposes, earthwork shall be classified as follows:

1. Excavation - Common: All excavation involved in grading and construction of the trackway, parking areas, landscaped areas, walkways, roads, driveways, and connections thereto; and any other excavation classified or indicated as common excavation.

2. Excavation - Rock: Includes removal of material in place which cannot be loosened or broken down with one pass of a crawler tractor weighing not less than 55,000 pounds, with a maximum draw-bar pull of not less than 57,000 pounds-force, pulling a single 24-inch hydraulic ripper tooth approved by the tooth manufacturer for use with the tractor under full hydraulic down pressure, or equipment of equivalent ripping capacity.

3. Structure Excavation: The removal of material for the construction of foundations for aerial structures, bridges, buildings, retaining walls, headwalls, cut-and-cover subways, and other structures, and such other excavation indicated as structure excavation.

4. Structure Backfill: Structure backfill includes furnishing structural fill material, and placing and compacting structural fill material around structures to the lines and grades indicated. Structure backfill includes borrow excavation and material when required.

5. Fill for Raising Grade: Includes raising of sub grade or grade to indicated elevation with structural fill, including moisture-conditioning and compaction of placed fill material. Structural fill material includes borrow excavation and material when required.

6. Pervious Backfill: Includes furnishing, placing, and compacting pervious backfill material behind abutments, wingwalls, and retaining walls, as indicated.

7. Common Embankment: Used only for embankment construction, above surrounding grade, below 2.5 feet of the finished embankment grade or sub grade, and where there are no foundation-bearing concrete structures above. Common embankment includes borrow excavation material when required.

8. Select Embankment: Used only for embankment construction, above surrounding grade, within 2.5 feet of the finished embankment grade or sub grade. Select embankment includes borrow excavation material when required.

9. Subsurface Extraction: Includes removal of abandoned utilities, tanks, walls, foundations, and other miscellaneous subsurface man-made structures that interfere with new construction and are designated to be removed, and the cleaning of such items if they are indicated to be salvaged. Removal of such obstructions at or above grade is specified in Section 02 41 00, Demolition.

10. Salvaging Topsoil: Salvaging topsoil is the removal of topsoil to the depth indicated, stockpiling the material on-site, and maintaining the stockpile until the material is reused in the work. Salvaging of topsoil shall be classified the same as the excavation with which it is associated, but if no such classification can be made, it shall be classified as Excavation - Common.

1.07 DESCRIPTION

A. Provide excavation for trackway and pavement; excavation and placement of compacted fill and backfill for structures, cut-and-cover subways, and subsurface and surface drainage; placement of pervious backfill; construction of embankments; sub grade and foundation preparation; subsurface extraction of miscellaneous structures and facilities indicated or required to be removed; and finish grading.

1.08 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Quality Plan: Refer to Section 01 43 00, Quality Assurance, and Section 01 45 00, Quality Control, for general requirements. The Quality Plan shall include a schedule of all tests specified to be performed by the Contractor.

C. Test Reports: Submit certified test reports of all tests specified to be performed by the Contractor. Test reports shall be sealed and signed by a California registered geotechnical engineer when required to meet requirements of the California Building Code, Safeguards During Construction, Chapter 33, and Structural Design Chapters 16 and 16A.

D. Samples: Furnish and deliver samples of fill and backfill materials as selected by the Engineer for testing and analysis.

E. Delivery Tickets: Submit a delivery ticket with each load of imported borrow material delivered to the site, stating the type of fill material and the quantity.

F. Field Verification for In-Situ Treatment: Submit the proposed program for field verification of Standard Penetration Test “N” Values after in-situ treatment for mitigation of liquefaction potential.

1.09 REGULATORY REQUIREMENTS

A. Regulatory requirements that govern the work of this Section include the following governing codes:

1. California Code of Regulations, Title 8, Division 1, Chapter 4, Subchapter 4, Construction Safety Orders.

2. California Code of Regulations, Title 24, Part 2, California Building Code, Chapter 33 and Structural Design, Chapters 16 and 16A.

1.10 QUALITY CONTROL

A. Quality Plan: The Contractor shall submit a Quality Plan, conforming to the requirements of Section 01 43 00, Quality Assurance, and Section 01 45 00, Quality Control, covering all earthwork operations and the field quality control to be performed by the Contractor.

B. Quality Control: The Contractor shall provide proper quality control measures to assure compliance with specified requirements. Foundation and sub grade preparation and the placement and compaction of fills shall be performed under the surveillance of a California registered geotechnical engineer employed by the Contractor, as required to comply with the California Building Code, Chapter 33 and Appendix Chapter 33 and Chapters 16 and 16A.

C. Tests: The Contractor shall engage the services of an approved independent soils testing laboratory to perform tests.

D. Tolerances:

1. Construct finished surfaces to plus or minus 1/2-inch of the elevations indicated.

2. Complete embankment slopes to plus or minus six inches of the slope line indicated. Do not encroach on the trackway bed or roadbed.

3. Maintain the moisture content of fill material as it is being placed within plus or minus two percent of the recommended moisture content of the material.

1.11 SITE CONDITIONS

A. Unfavorable Weather Conditions:

1. Excavating, filling, backfilling, and grading work shall not be performed during weather conditions which might damage or be detrimental to the condition of existing ground, in-progress work, or completed work. When the work is interrupted by rain, excavating, filling, backfilling, and grading work shall not resume until the site and soil condition (moisture content) are suitable for compaction.

2. Sub grade shall be free from mud, snow, ice, and deleterious material when work is resumed.

3. Soil material that is too wet for compaction shall be left to drain, to be aerated and dried by disking and harrowing or other approved methods until the moisture content of the area is uniform and within the specified limits.

B. Prevention of Erosion: Comply with requirements specified in Section 01 57 00, Temporary Controls, and the following:

1. Prevent erosion of stockpiles, ditches, embankments, filled, backfilled, and graded areas until such time as permanent drainage and erosion control measures have been installed.

2. Perform “protective grading” to provide positive drainage and to minimize ponding of surface water.

PART 2 – PRODUCTS

2.01 FILL AND BACKFILL MATERIALS - GENERAL REQUIREMENTS

A. Material used for fill, backfill, and embankment construction shall be an inert, inorganic soil, free from deleterious substances, and of such quality that it will compact thoroughly without the presence of voids when watered and rolled. (Inorganic soil is defined as soil containing less than two percent by weight of organic material when tested in accordance with ASTM D2974). Excavated on-site material will be considered suitable for fill, backfill, and embankment construction if it is free from organic matter and other deleterious substances and conforms to the requirements specified herein.

B. Excavated material that is suitable for fill, backfill, and embankment construction shall be conditioned for reuse and properly stockpiled for later filling and backfilling operations. Conditioning shall consist of spreading material in layers not to exceed eight inches and raking free of debris and rubble. Rocks exceeding six inches in largest dimension and deleterious material shall be removed from the site and disposed of as specified herein under Article 3.03G, Disposal of Surplus Material.

C. Where conditions require the importing of fill or backfill material, the material shall be an inert soil or soil-rock material free of organic matter and meeting or exceeding the minimum requirements specified herein for the location.

D. All material to be used for filling, backfilling, and embankment construction requires written approval of the Engineer.

2.02 FILL AND BACKFILL MATERIALS - SPECIFIC REQUIREMENTS

A. Common Fill: Well-to moderately well-graded soils consisting of sands, silts, and clays, with or without gravel, as excavated, screened or blended, having the following mechanical properties and gradation:

1. Gradation (ASTM D6913/D6913M):

Sieve Opening	Percent Passing, by Weight
6-inch square	100
3/4-inch square	70 minimum

2. Liquid Limit (ASTM D4318): 50 maximum

3. Plasticity Index (ASTM D4318): 25 maximum

B. Common Embankment: Common fill, with the following additional requirements:

1. Liquid Limit (ASTM D4318): 40 maximum

2. Plasticity Index (ASTM D4318): 15 maximum

C. Select Embankment: Well-to moderately-graded soils consisting of sands, silts, and clays, with or without gravel, as excavated, screened or blended, having the following mechanical properties and gradation:

1. Gradation (ASTM D6913/D6913M):

Sieve Opening	Percent Passing, by Weight
1 inch square	100
3/8 inch square	75 minimum
U.S. No. 4	20 minimum
U.S. No. 200	35 maximum

2. Sand Equivalent (Calif. Test 217): 10 minimum

3. Plasticity Index (ASTM D4318): 10 maximum

D. Structural Fill: Well to moderately-graded granular soils, as excavated, screened or blended, having the following mechanical properties and gradation:

1. Liquid Limit (ASTM D4318): 25 maximum

2. Plasticity Index (ASTM D4318): 6 maximum

3. Gradation (ASTM D6913/D6913M):

Sieve Opening	Percent Passing, by Weight
3 inch square	100
U.S. No. 4	35 minimum
U.S. No. 30	20 minimum
U.S. No. 200	25 maximum

4. Sand Equivalent (Calif. Test 217): 20 minimum

E. Pervious Backfill: Clean washed gravel or crushed stone, natural sands, manufactured sand, or combination thereof, conforming to the following requirements:

1. Gradation (ASTM C136/C136M):

Sieve Opening	Percent Passing, by Weight
2 inches square	100
U.S. No. 50	0-100
U.S. No. 100	0-8
U.S. No. 200	0-4

2. Percentage wear

   (ASTM C131/C131M or C535): 50 percent maximum

3. Soft fragments as a function of percent wear: 15 percent maximum

4. Coal and lignite: 0.25 percent maximum

5. Clay Lumps: 0.25 percent maximum

6. Other deleterious material: 2.0 percent maximum

2.03 MATERIALS FOR EARTHWORK

A. Fill and Backfill Materials: Where specific fill, backfill, and embankment materials are not indicated on Contract Drawings, conform to the following requirements:

1. Embankment: Common embankment below 2.5 feet for finished sub grade; select embankment for top 2.5 feet of finished sub grade.

2. Fill for Raising Grade: Structural fill beneath foundations and for sub grade below structures. Fill for raising grade under pavements and trackways shall be sub base material as specified in Section 32 11 17, Aggregate Sub base Courses.

3. Backfill Against Concrete Walls and Waterproofing: Structural fill or pervious backfill as indicated.

4. Backfill for Wing Walls, Retaining Walls, and Abutments: Structural fill or pervious backfill as indicated.

5. Fill or Backfill Under Supporting Walls and Columns and Similar Locations: Class 4000 concrete.

6. Backfill Where Not Otherwise Indicated: Common fill.

B. Topsoil to be Salvaged: Only existing topsoil which meets the requirements of Section 32 90 00, Planting, shall be salvaged. Topsoil that does not meet requirements specified in Section 32 90 00, Planting of the Contract Specifications shall be classified as Unsuitable Material and shall be removed from the site as herein specified under Article 3.03G, Disposal of Surplus Material.

2.04 SOURCE QUALITY CONTROL

A. Fill, backfill, and embankment materials proposed to be used in the work shall be tested in the laboratory for compliance with specified requirements as follows:

1. Moisture-Density Relationship: ASTM D1557.

2. Moisture Content: ASTM D2216.

3. Liquid Limit: ASTM D4318.

4. Plastic Limit and Plasticity Index: ASTM D4318.

5. Percentage of Wear: ASTM C131/C131M or C535 as applicable.

6. Sieve Analysis: ASTM D6913/D6913M, and ASTM C136/C136M, as applicable.

7. Percent Passing No. 200 sieve: ASTM D1140.

8. Sand Equivalent: California Test 217.

9. Organic Content of Soils: ASTM D2974.

B. Where classification of soils is necessary to meet specified requirements, perform laboratory tests in accordance with ASTM D2487.

C. Submit certified test reports of all tests as herein specified under Submittals.

D. Provide samples as requested by the Engineer for preparing checklists. Provide three samples of each type of material proposed for use from locations selected by the Engineer.

PART 3 – EXECUTION

3.01 STAKING AND GRADES

A. Lay out the work, establish all necessary markers, bench marks, grading stakes, and other stakes as required, in accordance with the requirements specified in Section 01 71 23, Field Engineering.

B. Install settlement markers at locations and elevations as determined by the Engineer. Comply with the requirements of Section 31 09 00, Geotechnical Instrumentation and Monitoring of Earthwork.

3.02 EXISTING UTILITIES

A. Verify on site the location and depth (elevation) of all existing utilities and services before performing any excavation work. Refer to Section 33 05 25, Support and Protection of Utilities, for additional requirements. Excavation within three feet of an active utility line shall be performed by hand.

B. Abandoned sewers, piping, and other utilities encountered in the progress of the excavating shall be removed and the ends plugged.

C. Active utility lines encountered, which are not indicated in the Contract Documents, shall be reported immediately to the Engineer and utility owners involved. The Engineer and utility owners shall be permitted free access to determine the measures deemed necessary to repair, relocate, or remove the utility.

3.03 EARTHWORK GENERAL REQUIREMENTS

A. Dust Control: Refer to Section 01 57 00, Temporary Controls, for dust control requirements.

B. Erosion Protection: Prevent erosion of the site at all times. Construct temporary berms and dikes and cut temporary swales to promote natural drainage of site. Refer to Section 01 57 00, Temporary Controls, for additional requirements.

C. Construction Traffic: Disperse travel paths of traffic and construction equipment over entire width of compacted surfaces so as to aid in obtaining uniform compaction. Protect exposed soil layers with high moisture content from excessive wheel loads.

D. On-Site Excavation or Borrow Pits: Do not excavate or remove any material from the project site or right-of-way which is not within the designated excavation, as indicated by the slope and grade lines, without written authorization from the Engineer.

E. Salvaging Topsoil:

1. Salvage topsoil from stripped and excavated areas, and stockpile on the site at appropriate locations. Prevent topsoil from contamination by other materials, and provide adequate drainage and erosion protection.

2. Place stockpiled topsoil in areas to be landscaped as indicated on the Contract Drawings.

F. Stockpiling of Fill and Backfill Material:

1. Excavate and separately stockpile suitable fill and backfill material, as indicated, during the progress of the excavation work. Save sufficient suitable excavated material, if available, for later filling, backfilling, and embankment construction.

2. Store materials from required excavations that are suitable for fill, backfill, and embankment as excavated, in stockpiles segregated by type.

3. Establish excavated material stockpiles on site only in locations where they will not interfere with the progress of the work. Offsite stockpiling, if necessary, shall be the responsibility of the Contractor.

G. Disposal of Surplus Material:

1. Excess earth materials, unsuitable materials, and debris shall become the property of the Contractor and shall be removed from the site and disposed of in a legal manner.

2. Location of disposal site and length of haul shall be the Contractor's responsibility.

H. Maintenance of Excavations, Slopes, and Embankments:

1. Excavate and remove material outside the limits of the excavation which is unstable and constitutes potential slides, and material which comes into excavations for any reason including from the driving of piles.

2. Maintain slopes and embankments until substantial completion and acceptance of the work. Promptly repair slides, slipouts, washouts, settlements, and subsidences that occur for any reason, and refinish the slope or embankment to the indicated lines and grades.

3. Refer also to Section 31 35 00, Slope Protection, for requirements.

I. Safeguarding of Structure Walls: Heavy equipment and rollers greater than one ton shall not be operated within four feet of structure walls.

3.04 SUBSURFACE EXTRACTION

A. Remove subsurface facilities and obstructions to the extent indicated.

B. When subsurface facilities are encountered during excavation which interfere with new construction, and such facilities are not indicated, notify the Engineer promptly for corrective determination.

3.05 ROUGH GRADING AND FILLING

A. Prior to commencement of earthwork, perform such soil and rock removal and filling as may be required to facilitate the progress of the work and bring all elevations to the rough grading lines indicated on the Contract Drawings. Grading shall be performed by blading or as herein specified under Article 3.08.

B. Fill or backfill, test pits, or holes which will not be completely removed by excavation, with lean concrete, pervious backfill, or clean structural fill, and compact as herein specified in layers not exceeding eight inches of uncompacted thickness.

C. Fill or backfill holes, swales, and low points that will not otherwise be removed in the course of the work to the indicated grades.

3.06 EXCAVATION

A. General Excavation Requirements:

1. Perform excavating as indicated in the Contract Documents and required for trackway and roadway beds, for concrete footings, foundations, retaining walls, exterior paving, floor slabs, concrete walks, and for site levels and grading, and provide shoring, bracing, underpinning, cribbing, pumping, and planking as required.

2. The bottoms of excavations shall be level, firm, undisturbed earth, clean and free from loose material, debris, and foreign matter.

3. Excavate to the lines and grades indicated on the Contract Drawings.

4. Excavations shall be supported and maintained by providing structural support of earth walls as specified in Section 31 50 00, Excavation Support and Protection, so that sides are stable and will not move. Excavations may be maintained by sloping cut faces where space permits, if calculations, sealed and signed by a civil or structural engineer currently registered in the State of California, show that the slopes are safe. Calculations shall consider all existing conditions, including adjacent traffic, construction loading, and other local effects.

5. Limits of excavations shall allow for adequate working space for installing forms, wall waterproofing, and as required for safety of personnel. Cut excavations in solid rock accurately to the lines indicated on the Contract Drawings, or to the width of the ductbank or concrete encasement.

6. Dewater excavation as specified in Section 31 23 19, Dewatering. Construct berms around excavations as required to prevent surface water and runoff from entering the excavation.

7. Remove unstable bottom material. Remove large stones, debris, and compressible soils from excavation bottoms to a minimum depth of 12 inches. Where required to excavate to rock, it shall be understood to mean sound bedrock. Remove loose and unsound material.

8. Except as otherwise indicated in the Contract Documents, preserve the material below and beyond the lines of excavations. Where an excavation is carried below the indicated grade, backfill to the indicated grade as herein specified.

9. Excavations for convenience of the Contractor shall be approved by the Engineer.

10. Place excavated material at a sufficient distance from edge of excavation so as not to cause cave-ins or bank slides, but in no case closer than three feet from the edge of excavations.

11. Unauthorized over excavations for footings and foundations shall be filled with lean concrete to indicated elevations.

12. Excavated earth material that is suitable for fill, backfill, or embankment shall be conditioned for re-use and properly stockpiled for later filling and backfilling operations as herein specified. Test, screen, and mix as necessary to meet specified requirements.

B. Rock Excavation:

1. Rock which cannot be broken up and removed by ripper equipment shall be excavated and removed by drilling and blasting. The use of explosives requires written approval of the Engineer as specified in General Conditions Article GC7.11.

2. Use pre-splitting to establish a shear plane in the rock along the cut periphery or proposed break lines to reduce overbreakage. Pre-split a periphery plane to the depth to be excavated prior to other blasting within the limits of that particular plane; except that the Contractor will not be required to pre-split to slopes flatter than one-to-one. Pre-split by drilling appropriately sized holes at intervals of not more than three feet, to the depth of the cut, along the plane of the proposed cut; load and stem such holes with an appropriate light charge explosive, and detonate all holes in the particular plane simultaneously.

3. If the depth of the cut is more than can be drilled from the top, an 18-inch offset will be allowed in the slope to begin succeeding drilling operations. The end result shall be a relatively smooth shear plane with localized irregularities which do not exceed two feet behind or one foot in front of the shear plane surface and which do not extend within the indicated lines of the excavation.

4. Where footings or foundations are to be placed on rock which is not horizontal, key the center of the foundation approximately 12 inches in depth throughout an area approximately equal to the dimensions of the column or footing to be placed on the rock, or the entire width of the slab, at not more than ten-foot intervals. Remove loose fragments, and clean and fill all seams with lean concrete.

5. Material excavated beyond or below the indicated cross section shall be at the Contractor's expense. Fill overbreakage to required invert with lean concrete at no additional expense to the District.

6. Leave the side slopes of rock cuts with reasonably uniform faces whether the excavation is carried beyond the specified side slopes or not. Remove all loose rock on cut slopes immediately after blasting. Sloped surfaces shall conform to the typical section indicated or to natural cleavage planes, where these are compatible with the typical section.

7. Exposed rock faces shall be mapped by a Contractor-employed, California-registered geotechnical engineer or engineering geologist. If structural mapping indicates that unstable planes or other features are exposed which jeopardize the stability of the slope, the Contractor shall modify the slope as required.

3.07 EMBANKMENT CONSTRUCTION

A. Construct embankments to lines, grades, and contours indicated, in layers as nearly uniform and horizontal as is consistent with the indicated finished contour and profile. Maximum thickness of the layers shall be eight inches before compaction.

B. Compact each layer to specified density for entire width of the embankment. Achieve required compaction by rolling with compaction equipment suitable for type and condition of the particular material. Roll in a longitudinal direction parallel to longest dimension, starting at outer edges and progressing toward the center.

C. Moisture-condition embankment fill material as required to achieve its compaction to the specified density, within the tolerances specified herein.

D. Do not compact material that contains excessive moisture. In such cases, scarify to the full depth of the layer having excessive moisture content and dry by reworking, mixing with dry materials, or other approved methods.

E. Remove material that cannot be compacted to required density within specified tolerances, and replace with suitable material.

F. Where pipes, culverts, or structures extend into embankments, construct embankment to at least two feet over and ten feet on either side of the pipe, culvert, or structure location prior to excavation.

G. Where fill is to be placed against hillsides or slopes steeper than five to one (horizontal to vertical), the existing slope shall be benched at least six feet horizontally into the hillside as the new embankment is placed in horizontal lifts.

H. Do not commence final shaping until above specified requirements have been completed. Shape entire surface of the slopes of cuts and embankments to true grade, alignment, and cross section indicated. Leave cut slopes in rock with uniform surface, and remove all loose overhanging rock.

3.08 SUBGRADE PREPARATION

A. Perform all cutting, blading, and shaping as required to cut and shape the sub grade to the grades and elevations indicated.

B. Sub grade preparation includes fine grading, reworking as necessary, and preparation of cut, fill, or embankment upon which the structure and equipment foundations, pipe, sub ballast, sub base, base, and pavement will be placed. Remove unsuitable sub grade material, such as weak or compressible soils.

C. Scarify and mix entire surface of sub grade to a depth of at least six inches. Moisture-condition scarified sub grade to three percent above optimum moisture content. If sub grade stabilization material is required, incorporate it into the sub grade at this time.

D. After the material has been thoroughly mixed and moisture-conditioned, accurately construct and fine grade the sub grade to indicated line, grade, and contour with high and low spots eliminated. Compact for full width to the specified density. Remove soft spots developed during working, fill with approved material, and re-compact.

E. Finish sub grade to straightedge or template within specified tolerances with the finished surface bladed to a uniform, dense, smooth texture.

3.09 FOUNDATION PREPARATION

A. Complete construction of the excavation support and dewatering systems prior to construction of structure and equipment foundations.

B. Avoid disturbing bottom of excavation. If bottom is disturbed, restore and stabilize the bearing foundation with compacted pervious backfill material as specified herein.

C. If material at bottom of the excavation is rock, remove loose material and roughly level the bearing foundation to indicated elevation. If the bottom contains occasional rock outcroppings or rock in only a portion of the area, remove such rock to a depth of six inches below indicated sub grade and backfill with lean concrete.

D. Where unsuitable material is encountered at the elevations indicated for foundations, all soft, loose, or unsuitable material shall be removed. The area shall be scarified to a minimum depth of 12 inches, and the planned elevation shall be re-established by backfilling with structural backfill, moisture-conditioning, and compacting to a minimum dry density of 95 percent of the maximum laboratory dry density as determined in accordance with ASTM D1557. Where the exposed foundation consists of competent, undisturbed in-place soils, scarifying may be omitted.

3.10 SUBGRADE FILLING/RAISING GRADE

A. Compacted fill for raising of sub grade to indicated elevation shall be constructed by approved methods. Fill material shall be spread in uniform lifts not exceeding eight inches in uncompacted thickness. Fill material that does not contain sufficient moisture to compact properly shall be sprinkled with water; if it contains excess

moisture it shall be aerated or permitted to dry to the proper water content. Fill material and water shall then be thoroughly mixed before being compacted. Each layer of spread fill material shall be compacted to the specified density.

B. Control of fill shall consist of field inspection and testing to determine that each layer has been compacted to the required density and to ensure that optimum moisture is being obtained. Any layer or portion of a layer that does not attain the compaction required shall be scarified and re-compacted until the required compaction is obtained.

C. Spreading and compacting shall be performed as required to produce the required density and a uniform surface smooth and true to grade.

3.11 COMPACTION

A. Compaction Density: Compact each layer of embankment, fill, and backfill material to not less than the indicated or specified compaction. Required compactions are defined as Class I and Class II, as follows:

1. Class I Compaction: 90 percent relative compaction as determined by ASTM D1557.

2. Class II Compaction: 95 percent relative compaction as determined by ASTM D1557.

B. Required Compactions:

1. Embankment or Fill where the Surface will be Bearing Foundation: Class II for full depth. Where embankment construction exceeds five feet in depth, provide minimum Class I compaction below the top 2.5 feet.

2. Fill Below Trackways and Pavements: Class II for full depth. Where fill exceeds three feet in depth, provide minimum Class I compaction below the top three feet.

3. Backfill around Structures: Class I under top 12 inches; Class II for top 12 inches.

4. Cut-and-Cover Backfill: Class I to 36 inches above structure or utility; Class II for balance, with a minimum of Class II for top 12 inches.

5. Original Ground or Cut Sub grade: Except as specified in Articles 3.08 and 3.09 where original ground or cut sub grade, or fill less than one foot thick, will be sub grade or bearing foundation, scarify the surfaces and provide Class II compaction for at least eight inches in depth. Include the following additional requirements:

    a. Provide Class II compaction for original ground when such original ground is within 3.5 feet of top of rail profile or within 2.5 feet of finished pavement grade, for full width of trackway and pavement plus three feet on each side thereof.

    b. Provide Class II compaction for top six inches of undisturbed original ground upon which embankments are to be constructed.

6. Where not otherwise indicated or specified and where structures are not involved, provide Class I compaction to minimize settlement.

3.12 BACKFILLING

A. Use materials removed from site excavations if such material meets specified requirements.

B. Backfilling is required around all substructures. Fill all abandoned vaults, shafts, airways, adits, holes, pits, and other voids.

C. Place backfill in layers not to exceed eight inches of loose material, and compact each layer to specified density before the next layer is placed.

D. Place backfill material in such manner that unbalanced horizontal loads will not be applied to a newly placed structure or portion of structure, utility, or pipeline. Do not backfill around portions of structures requiring backfill on only one side or on less than all sides, until the concrete has reached the specified 28-day strength to withstand the earth pressures on structures.

E. When placing material for backfill around waterproofed structures, protect such structures and the waterproofing thereof with a shield when necessary to prevent displacement or injury by stones or other hard substances in the backfill.

F. Do not backfill on or against structural concrete until the specified 28-day concrete strength has been attained.

G. Complete backfill for end bents and abutments, including backfill for wingwalls, in accordance with the above specified time/strength limit. Step slopes behind abutments, unless otherwise indicated, to prevent backfill from acting as a wedge against the abutment. Provide drainage behind abutments and wingwalls as indicated.

H. Do not use compaction equipment and methods that produce excessive horizontal or vertical earth pressures on structures. Excessive horizontal earth pressures are those in excess of at-rest earth pressures. Excessive vertical earth pressures are those in excess of overburden pressures.

3.13 FINISH GRADING

A. Finish grade all areas to elevations and grades indicated. In areas to receive topsoil and landscape planting, finish grading shall be performed to a uniform seven to eight inches below the grades and elevations indicated.

B. Place and spread stockpiled topsoil to a uniform thickness of six inches (approximately) in areas to receive topsoil and landscape planting. Place and spread to a uniform thickness approximately one inch below finish grades indicated.

C. Coordinate with the requirements of Section 32 90 00, Planting.

3.14 FIELD QUALITY CONTROL

A. Regulatory Requirements: In compliance with the California Building Code, Chapter 33, the Contractor's earthwork operations shall be performed under the observance and inspection of a Contractor-employed geotechnical engineer currently registered in the State of California, as follows:

1. Site preparation, cutting and shaping, excavating, filling, backfilling, and embankment construction shall be carried out under the inspection of the geotechnical engineer, who will perform appropriate field and laboratory tests, as determined by the geotechnical engineer, to evaluate the suitability of fill and backfill material, the proper moisture content for compaction, and the degree of compaction achieved. Fill or backfill that does not meet the specified requirements shall be removed or recompacted until the requirements are satisfied.

2. Cutting and shaping, excavating, conditioning, filling, backfilling, and compacting procedures require approval of the geotechnical engineer as they are successively performed. Work found to be unsatisfactory or work disturbed by subsequent operations before approval is granted shall be corrected in an approved manner as approved by the geotechnical engineer.

B. Density Tests: Compacted fill, backfill, and embankment shall be tested to verify compliance with specified requirements in accordance with ASTM D6938. Frequency of tests shall be in accordance with the Contractor's Quality Plan, but not less than the following:

1. Expansive Horizontal Areas: One test per 100 cubic yards, or fraction thereof, of fill or backfill placed.

2. Confined Areas and Embankments: One test per every second lift of fill, backfill, or embankment placed.

C. Compaction Tests: Tests for compaction shall be performed in accordance with test procedures specified in ASTM D1557, as applicable. Field-testing of soils or compacted fill in place shall be performed in accordance with applicable requirements of ASTM D6938.

D. Moisture Content Tests: Compacted fill, backfill, and embankment shall be tested to verify compliance with specified requirements in accordance with ASTM D6938. Minimum frequency of tests shall be as specified above for density tests.

END OF SECTION 31 00 00

SECTION 31 09 00

GEOTECHNICAL INSTRUMENTATION AND MONITORING OF EARTHWORK

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Boreholes insulations.

B. Observation wells.

C. Inclinometer system.

D. Type 1 settlement marker.

E. Type 2 settlement marker.

F. Identification devices for inclinometers, observation wells, and settlement markers.

G. Replacement parts and supplies.

1.02 RELATED SECTIONS

A. Earthwork requirements are specified in Section 31 00 00, Earthwork.

B. Requirements for dewatering are specified in Section 31 23 19, Dewatering.

C. Shoring and underpinning for existing structures are specified in Section 31 40 00, Shoring and Underpinning.

D. Excavation support systems are specified in Section 31 50 00, Excavation Support and Protection.

1.03 MEASUREMENT AND PAYMENT

A. Measurement: Earthwork instrumentation will be measured for payment by the lump-sum method, acceptably performed and completed.

B. Payment: Earthwork instrumentation will be paid for at the Contract lump-sum price, as indicated in the Bid Schedule of the Bid Form.

1.04 SUBMITTALS

A. General: Refer to Contract Specifications Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures. Submittals for earthwork instrumentation shall be submitted to the Engineer for review and approval.

B. Information, Drawings, and Data: Submit the following listed information, instructions, drawings, and data:

1. Manufacturer's installation instructions and recommendations for installation of instrumentation;
2. Detailed plan of instrumentation locations;
3. Proposed schedule for installing instrumentation;
4. Two sets of operating manuals, specifications, calibration certificates for each instrument, and descriptions of each type of instrument, including read-out devices and appurtenant supplies required for a complete instrumentation installation;
5. Manufacturer's product data for lockable access covers;
6. Boring logs for each hole where instrumentation will be installed; and
7. Materials and mix proportions for grout backfill.

C. Permits: Submit copies of special permits required by jurisdictional authorities for installation of observation wells and inclinometers.

D. Qualifications: Submit qualifications of the personnel proposed to install and maintain instrumentation services.

1.05 QUALITY ASSURANCE

A. Installation and calibration of instruments shall be performed by an individual or organization which is regularly engaged in, and that maintains a regular force of personnel skilled in, the installation and maintenance of instrumentation of the types specified herein.

B. The Contractor shall install, maintain, and calibrate the instruments in accordance with the instrument manufacturer's recommendations.

1.06 REGULATORY REQUIREMENTS

A. Comply with applicable requirements of the California Code of Regulations, Title 8, Division 1, Chapter 4, Subchapter 4, Construction Safety Orders.

1.07 SITE CONDITIONS

A. Instrumentation shall be maintained by the Contractor.

B. Damaged or non-functional installations shall be replaced by the Contractor immediately, at no cost to the District.

C. Provide access to monitoring instruments, and facilitate monitoring by temporarily stopping or interrupting certain portions of the Work as may be required for monitoring and taking readings. Perform monitoring and measuring in a manner that will not delay the work unnecessarily, and schedule and perform the work in a manner that will not delay monitoring and measuring.

1.08 SEQUENCING AND SCHEDULING

A. Schedule installation of instrumentation to be performed in advance of excavation work.

B. Observation wells and inclinometers shall be installed in time to allow observations at least 10 days before excavation in the vicinity begins.

PART 2 – PRODUCTS

2.01 BOREHOLE INSTALLATIONS

A. Steel casings shall be employed where necessary to avoid caving of the hole.

B. Grout shall be Class 2000 concrete in accordance with Section 03 05 15, Portland Cement Concrete; maximum aggregate size: 3/8 inch.

C. Lean concrete where required shall comply with requirements of Section 03 05 15, Portland Cement Concrete.

D. Access cover shall be heavy-duty cast or forged steel frame with solid lid and locking device, of dimensions appropriate to the borehole diameter.

E. Provide asphalt pavement repair materials as required in accordance with Section 32 11 23, Aggregate Base Courses, and Section 32 12 16, Asphalt Paving.

2.02 OBSERVATION WELLS

A. Provide standpipe observation wells, each consisting of a Schedule 40 PVC tube with a slotted end section that can be isolated at the appropriate level. The observation wells shall be installed in boreholes. Access to the top of observation well shall be provided. The observation well top shall be protected against vandalism.

2.03 INCLINOMETER SYSTEM

A. Provide an inclinometer system with sensitivity of plus or minus 0.001 foot per 2 feet of casing, and total system accuracy of 0.3 inch per 100 feet of casing. Provide biaxial sensors in waterproof housings, with 0.42-inch outside diameter 6-conductor cable, 1/16-inch stranded steel core, and waterproof neoprene cover with external marks at 1-foot intervals.

B. Provide a combination readout instrument, data storage and retrieval system, and microcomputer to digitize and store inclinometer readings, and to present the data for immediate representation by the printer in either tabular or graphic form, or both. The system shall allow editing, correction and adjustment of data, and shall provide error-checking routines. In addition, the system shall have the following capabilities and accessories:

1. At least 10,000 data points distributed in a maximum of 40 data sets;
2. Splash-proof with waterproof connections;
3. Rechargeable battery with a capacity adequate for eight hours of operation in "Record" mode at 70 degrees Fahrenheit, without printer operation; and
4. "Power on" and "Low Battery" indications.

C. Casing shall be aluminum or plastic pipe with internal longitudinal grooves, and with telescoping couplings, caps, and fittings, as indicated or required. Casing shall have a minimum inside diameter of 3 inches.

D. Provide inclinometer sensor with 100 feet of cable and one data recorder-processor manufactured for the purpose.

2.04 TYPE 1 SETTLEMENT MARKER

A. Provide 1-inch long, powder-actuated concrete nail, set approximately 7/8-inch deep with head exposed in top of concrete or asphalt concrete. The nail shall be set a minimum of 3 inches from any edge of concrete to avoid damage to the structure.

2.05 TYPE 2 SETTLEMENT MARKER

A. Provide 3/4-inch diameter by 5-feet long deformed reinforcing bar in accordance with requirements of Section 03 20 00, Concrete Reinforcing. Reinforcing bar shall be driven into the ground, centered in a 6-inch deep, 1-foot diameter hole.

B. Provide cast or forged steel frame and cover, with cover being lockable or provided with locking device.

C. Center the frame and cover over the reinforcing bar and place grout in the annulus between soil and cover in hole. Top of cover and grout shall be level with adjacent ground surface.

2.06 IDENTIFICATION DEVICES FOR INCLINOMETERS, OBSERVATION WELLS, AND SETTLEMENT MARKERS

A. Provide an alpha-numeric identifier at each inclinometer, observation well, and settlement marker location.

B. Identification devices shall be selected as appropriate to each individual location and shall consist of materials that can be removed at the end of the Contract, leaving no residual effect on the mounting surface.

2.07 REPLACEMENT PARTS AND SUPPLIES

A. Provide replacement parts and other equipment and materials required for operation of the instrumentation equipment throughout the life of the Contract.

PART 3 – EXECUTION

3.01 LOCATIONS

A. Install observation wells, settlement markers, and inclinometers as indicated. All locations shall be field verified before installation. Install the instruments as close as practicable to the locations indicated, based upon actual conditions in the field.

B. After the instruments have been installed or, if damaged, repaired and reinstalled, prepare drawings and a report summarizing the installation of each instrument. Include the following information:

1. Instrument identification number and type;
2. Principal features of the work and existing construction;
3. Installation procedures and the date of installation;
4. The “as installed” configuration of each instrument, including depths, lengths, elevations, station, offset, and other dimensions of key elements of each installed instrument; and
5. Verification that inclinometer casings meet specified tolerances for alignment of longitudinal grooves and vertical inclination.

3.02 INSTALLATION

A. Boreholes:

1. For each hole, maintain a log, recording soil and groundwater conditions encountered.
2. Verify that the hole is drilled so that the instrument casing, when installed, is within two degrees of vertical (plumb) throughout its length and is at the correct depth.
3. When the drill hole will not remain open, advance the drill hole using a steel outer casing or an approved drilling fluid. Withdraw outer casing after instrument casing is installed and as the hole is being backfilled. Steel outer casings shall remain the property of the Contractor.
4. Fill annular void between drill hole and instrument casing as indicated.

B. Observation Wells:

1. Install observation wells as indicated.
2. Install a well-drained, lockable surface box for every observation-well installation.

C. Settlement Markers: Install settlement markers as indicated.

D. Inclinometer System:

1. Install inclinometer casing as indicated.
2. Orient inclinometer casing so that the orthogonal grooves are positioned parallel and perpendicular to the excavation. Cap the top of the casing.
3. Install inclinometer a minimum of 10 feet below bottom of excavation.
4. Verify that inclinometer casings meet specified tolerances for alignment of longitudinal grooves and vertical inclination.

3.03 PROTECTION AND MAINTENANCE

A. Access covers shall be lockable and keyed alike. Provide three keys for each cover to the Engineer.

B. Protect and maintain all instruments. Keep protective covers locked. Maintenance shall include draining or flushing the terminal boxes and piezometers.

C. Repair or replace damaged or missing instrument components or entire instruments as required within 5 days. Damage to any instrumentation shall be repaired by the Contractor.

3.04 REMOVAL OF INSTRUMENTS

A. Prior to Substantial Completion, remove and dispose of settlement markers and the top three feet of casings for inclinometers.

B. Plug remaining open portions of settlement markers with lean concrete. Construct new pavement repair in paved areas of the same material and to the same thickness as existing adjacent pavement. Restore disturbed or damaged surfaces to the conditions existing prior to the installation of the instruments.

C. Abandonment of observation wells and inclinometers shall conform with the requirements of jurisdictional authorities.

D. Remove instrumentation identification devices and protective barriers.

3.05 INSTRUMENTATION PROGRAM

A. Refer to the Contract Specifications, Section 31 09 00, Geotechnical Instrumentation and Monitoring of Earthwork, for specific requirements.

END OF SECTION 31 09 00

SECTION 31 11 00

CLEARING AND GRUBBING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Care of existing trees and tree protection fencing

B. Clearing and grubbing

C. Tree trimming

D. Tree removal

E. Nesting bird surveys

F. Demolition and removal

G. Disposal of removed materials and debris

H. Salvage

I. Backfill

1.02 RELATED SECTIONS

A. Temporary facilities, such as fences, barricades, warning lights, and other temporary safety measures, are specified in Section 01 52 00, Construction Facilities.

B. Dust control is specified in Section 01 57 00, Temporary Controls.

C. Demolition of structures and removal, salvage, or other disposition of slabs, footings and foundations; existing pavement, curbs and gutters, sidewalks, headwalls, walls, and steps; utility service facilities; guardrail and posts, highway and street signs and fences; and other miscellaneous structures and site improvements that interfere with new construction are specified in Section 02 41 00, Demolition.

D. Removal of items that are buried below grade is specified in Section 31 00 00, Earthwork.

1.03 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for the clearing and grubbing will be either by the lump-sum method or by the unit-price method as determined by the listing of the bid item for the clearing and grubbing indicated in the Bid Schedule of the Bid Form.

B. Lump sum: If the Bid Schedule indicates a lump sum for clearing and grubbing, the lump-sum method of measurement and payment will be in accordance with Section 01 20 00, Price and Payment Procedures, Article 1.02 Lump Sum Measurement.

C. Unit price: If the Bid Schedule indicates a unit price for clearing and grubbing, the unit-price method of measurement and payment will be as follows:

D. Measurement

Site clearing and grubbing will be measured for payment by the square foot method.

1. Removal of trees less than or equal to 6 inch diameter at breast height (DBH), nesting bird surveys for clearing and grubbing, tree trimming, stump removal, tree protective fencing, backfill, and, disposal of removed materials and debris will not be measured separately for payment, but will be included in the square foot unit measurement for site clearing and grubbing.

2. Tree removal will be measured for payment per each. Trees are defined as greater to 6 inch DBH. Measurement of tree removal shall include stump removal if stump is not within the clearing and grubbing boundary. Nesting bird surveys for tree removal will not be measured separately for payment, but will be included in the unit measurement for tree removal.

E. Payment

1. Site clearing and grubbing will be paid for at the indicated Contract prices, as determined by the measurement method specified in Article 1.03 D.

1.04 ADMINISTRATIVE REQUIREMENTS

A. Preconstruction Meeting: Conduct meeting at Jobsite to comply with requirements in Section 01 31 19, Project Meetings. Prior to start of construction the Contractor shall conduct a meeting with the Engineer to review tree work. Notify Engineer at least ten working days before convening meeting.

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, for submittal requirements and procedures.

B. Utility Severance Certificates: Provide certificates of severance of utility services, issued by the utility owners, for review and record purposes. Submit copies of certificates for record documents in accordance with the requirements of Section 01 78 39, Project Record Documents.

1.06 QUALITY ASSURANCE

A. Tree Service Qualifications: Contractor performing tree work shall possess a valid specialty class C61-D49 contractor's license. An experienced and professional tree service firm that has successfully completed tree removal and pruning work similar to that required for this project.

1.07 REGULATORY REQUIREMENTS

A. Regulatory requirements that govern the work of this Section include the following governing codes:

1. California Code of Regulations, Title 8, Division 1, Chapter 4, Subchapter 4, Construction Safety Orders

2. California Code of Regulations, Title 24, Part 2, California Building Code, Chapter 33, Safeguards During Construction

3. Migratory Bird Treaty Act (MBTA)

4. California Fish and Game Code – Section 3503, 3503.5, and 3513

1.08 JOBSITE CONDITIONS

A. Dispose of cleared, grubbed, and removed material away from the Jobsite. Burying and burning of materials at the Jobsite is not be permitted. Stockpile salvaged material in a secured location.

B. Clear and restore areas used for the Contractor's convenience. Restore such areas to their original condition, and provide mulching, seeding, and planting as required.

C. Protect survey markers and monuments, existing improvements, and adjacent properties from removal and damage.

D. Give written notices to utility owners and municipal departments requesting discontinuance of services to areas that will be affected by the Jobsite clearing and grubbing work.

E. Provide noise and dust abatement as specified in Section 01 57 00, Temporary Controls.

PART 2 – PRODUCTS

2.01 MATERIALS AND EQUIPMENT

A. The Contractor shall furnish all materials, tools, equipment, facilities, and services as required for performing site clearing, grubbing and other site preparation work.

PART 3 – EXECUTION

3.01 PREPARATION

A. No construction roads shall be created within the drip lines of any trees or other vegetation designated to be saved without approval of Engineer.

B. If temporary haul or access roads shall pass over the tree root area to remain cover with a 4 to 6 inch layer of mulch.

C. Make provisions for salvaging and disconnecting, capping, and temporarily supporting any irrigation lines as directed by Engineer.

3.02 NESTING BIRD SURVEYS

A. Nesting Bird Surveys: If construction activities require the removal or trimming of any trees or shrubs during the nesting season (February 1 to August 31), the Contractor shall conduct a preconstruction survey for nesting birds within the immediate footprint of Jobsite. Nesting survey shall be completed by a qualified biologist or comparable qualification to be approved by the Engineer. If active nests are found in any impact areas, the qualified biologist shall assess the potential impacts of construction to ensure an appropriate buffer is established to protect the active nests. If no active nests are found, no further surveys are required. However, if two weeks lapse during construction within the active nesting period, then the survey shall be repeated to ensure that any nests have not been occupied or created during the work stoppage.

3.03 CLEARING AND GRUBBING

A. Perform clearing and grubbing as necessary to remove trees, shrubs, other vegetation and deleterious material from the Jobsite. Remove stumps, roots larger than 2 inches in diameter, matted roots, logs, organic or metallic debris, and other deleterious material to a depth of not less than 18 inches below exposed subgrade.

B. Do not remove trees, shrubs, or other vegetation indicated to remain or to be relocated.

C. Use only hand methods or air spade for grubbing within protection zones.

D. Do not start earthwork operations in areas where clearing and grubbing are not complete, except that stumps and large roots may be removed concurrently with excavation.

E. Where the work includes requirements for wood chip mulch, acceptable material from clearing and grubbing activities may be used to produce such mulch per Engineer direction.

F. Fill depressions caused by clearing and grubbing operations with backfill in accordance with applicable requirements of Section 31 00 00, Earthwork. Compact backfill to make the surface conform with the original adjacent surface of the ground.

G. Prior to any cutting or filling, topsoil shall be stripped. See Contract Drawings and Section 31 00 00, Earthwork.

3.04 TREE TRIMMING

A. Remove tree branches overhanging trackways, roadways, and other designated areas of the Jobsite to within 20 feet of finish grade. Cut off branches neatly and close to the tree boles. Cut branches with sharp and clean pruning instruments; do not break or chop. Remove other branches as necessary to present a balanced appearance.

3.05 TREE REMOVAL

A. Remove trees indicated for removal on the Contract Documents.

B. Grind tree stumps to 18 inches (minimum) below finish grade. Fill depressions caused by stump grinding operations with backfill in accordance with applicable requirements of Section 31 00 00, Earthwork.

C. Do not remove trees, indicated to remain or to be relocated.

D. Prior to tree removal, erect protective fencing if, in the opinion of the Engineer, there is risk of damage caused by construction operations.

3.06 CARE OF EXISTING TREES

A. Trees and plants indicated in the Contract Documents to remain and to be preserved shall be protected from damage using tree protection fencing at, or near, the driplines of the trees and plants. Tree protection fencing shall be 4 feet tall orange snow fencing attached to T-post driven into the ground. Trees that are located in paved site conditions shall be wrapped with straw waddles and snow fencing to minimum height of 6 feet. Vehicles, equipment, materials, and debris shall not be placed or parked in these areas or under trees to remain.

B. Feed, water, and maintain protected trees and plants in a healthy, growing condition during the construction period.

3.07 DAMAGE TO EXISTING TREES

A. Trees damaged during construction shall be immediately repaired by a tree surgeon acceptable to the Engineer at the Contractor’s expense.

B. Tree judged by the accepted tree surgeon to be damaged beyond repair shall be removed at Contractor’s expense.

C. For each tree erroneously removed or damaged beyond repair, an assessment will be immediately withheld from Contractor's progress payments.

1. Assessment will be equal to the value of the tree prior to damage.

2. Assessment will be determined by a tree appraiser, selected by District and paid by Contractor.

3. The cost for hiring a tree appraiser shall be withheld from Contractor's progress payments.

D. Contractor shall replace each damaged tree with nursery-grown material of similar size and of the same or approved species.

1. Replacement trees shall be the greater of two 2 inch caliper or size equivalent to the size of the damaged tree and planted in accordance with Section 32 90 00 Planting.

3.08 DEMOLITION AND REMOVAL

A. Coordinate the work of this Section with the work of Section 02 41 00, Demolition, as required to remove existing pavements, curbs, structures and site improvements that interfere with new construction and where demolition is not indicated.

B. Remove walls and masonry construction to a minimum depth of 2 feet below existing ground level in areas where such items do not interfere with new construction.

C. Take possession of, remove, and dispose of abandoned rail and track materials.

D. Slabs may be broken for drainage and left in place where they are below grade and the Engineer determines it is not detrimental to the structural integrity of the fill or structure to be placed above.

3.09 DISPOSAL OF REMOVED MATERIALS AND DEBRIS

A. Dispose of removed materials, waste, trash, and debris in a safe, acceptable manner, in accordance with applicable laws and ordinances and as prescribed by authorities having jurisdiction.

B. Burying of trash and debris on the Jobsite will not be permitted. Burning of trash and debris at the Jobsite will not be permitted.

C. Remove trash and debris from the Jobsite at frequent intervals so that its presence will not delay the progress of the Work or cause hazardous conditions for workers and the public.

D. Removed materials, waste, trash, and debris shall become the property of the Contractor and shall be removed from the District's property and disposed of in a legal manner. Location of disposal site and length of haul shall be the Contractor's responsibility.

3.10 SALVAGE

A. Refer to Section 02 41 00, Demolition, for salvage requirements.

3.11 BACKFILL

A. Backfill trenches and excavations resulting from work under this Section in accordance with applicable requirements of Section 31 00 00, Earthwork.

END OF SECTION 31 11 00

SECTION 31 23 19

DEWATERING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Detection of movement

B. Dewatering

C. Records

D. Restoration

1.02 RELATED SECTIONS

A. Coordinate the work of this Section with the work of Section 31 40 00, Shoring and Underpinning, and Section 31 50 00, Excavation Support and Protection.

1.03 MEASUREMENT AND PAYMENT

A. General: Dewatering will not be measured separately for payment, and all costs in connection therewith will be considered incidental to the excavation to which the dewatering work pertains.

1.04 DESCRIPTION

A. Controlling and disposal of storm water runoff; lowering the water table and intercepting seepage which would otherwise emerge from the slopes or bottoms of excavations; increasing the stability of excavated slopes; preventing loss of material from beneath the slopes or bottoms of excavations; reducing lateral loads on sheeting and bracing; improving the excavating and hauling characteristics of sandy soil; preventing rupture or heaving of the bottom of an excavation; disposal of pumped water; and protection and restoration of adjacent structures, including repair of any settlement-related damage.

B. Constructing, maintaining, observing, and removing equipment and instrumentation when no longer needed.

1.05 DESIGN CRITERIA

A. The Contractor shall be responsible for the design and adequacy of the dewatering system. Design the dewatering systems to perform as follows:

1. Effectively reduce the hydrostatic pressure and lower the groundwater levels below the excavation;

2. Develop a substantially dry and stable sub grade for prosecution of construction operations;

3. Prevent damage to adjacent properties, buildings, structures, utilities, and other work as a result of settlement or other groundwater-related effects; and

4. Assure that, after 12 hours of initial pumping, no soil particles will be present in the discharge.

1.06 PERMITS

A. The Contractor shall obtain all special permits and licensing for dewatering and disposal of pumped water as required to construct and complete the Work.

1.07 SUBMITTALS

A. Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Submit pre-construction surveys, as specified in Article entitled “Site Conditions” herein.

C. Submit procedures for detection of movement, as specified in Article entitled “Detection of Movement” herein.

D. Prior to installation of the dewatering system, submit Shop Drawings and design data, indicating the following:

1. The proposed type of dewatering system;

2. Arrangement, location, and depths of system components showing new and existing facilities and utilities;

3. Complete description of equipment and instrumentation to be used, with installation, operation, and maintenance procedures;

4. Types and sizes of filters;

5. Design calculations demonstrating adequacy of the proposed system and equipment. The Contractor shall perform site-specific field testing to determine soil permeabilities to be used for design of the dewatering system;

6. Estimated discharge rates: and

7. Methods and locations of disposal of pumped water.

E. Submit copies of the special permits required for performing the work of this Section.

F. Submit records as required by Article entitled “Records” herein.

1.08 REGULATORY REQUIREMENTS

A. Comply with the California Code of Regulations, Title 8, Chapter 4, Subchapter 4 — Construction Safety Orders

B. Methods of groundwater discharge, conveying, and transmission to off-site locations shall meet with the approval of the governmental authorities having jurisdiction.

1.09 SITE CONDITIONS

A. Pre-construction Surveys: The Contractor shall submit to the Engineer, for review and approval, pre-construction surveys for existing structures and facilities located above or adjacent to the new construction and which may be affected by the work. These surveys shall include photographs, maps, plans, written descriptions, and surveyed foundation levels as necessary to fully document pre-construction conditions.

B. Surface Drainage: Intercept and divert precipitation and surface water away from excavations through the use of dikes, curb walls, ditches, pipes, sumps, or other means.

C. Drainage of Excavated Areas:

1. Provide and maintain ditches of adequate size to collect surface and seepage water which may enter the excavations. Divert the water into sumps and drain or pump into drainage channels or storm drains or sewers, subject to the approval of jurisdictional authorities.

2. When water is to be diverted into a storm drain, provide settling basins or other approved facilities as required to reduce the amount of fine particles which may be carried into the drain. If a storm drain becomes blocked or its capacity restricted due to dewatering operations, make arrangements with the jurisdictional authority, and clean the drain.

PART 2 – PRODUCTS

2.01 MATERIALS AND EQUIPMENT

A. The Contractor shall furnish all materials, tools, equipment, facilities, and services as required for providing the necessary dewatering work and facilities. Provide back-up equipment as necessary for replacement and for unanticipated emergencies.

B. Provide piezometers for monitoring groundwater levels and other instruments and measuring devices as required.

PART 3 – EXECUTION

3.01 DETECTION OF MOVEMENT

A. For each existing structure that may be affected by the work, install settlement markers on each footing, building corners, wall or surrounding structures to be monitored. Settlement markers shall be capable of being read to an accuracy of 0.005 foot.

B. Take and record readings not less than once per week during performance of the dewatering work until the permanent structure is complete to the ground level.

C. Stop work; notify the Engineer, and take immediate remedial action if movement of the existing structure occurs during performance of the work.

D. Upon completion of the dewatering work, take weekly readings of the measurement points for a period of 4 weeks, or longer if movement persists, and report the results to the Engineer.

E. The detection of movement shall be performed by a qualified licensed civil engineer or land surveyor.

3.02 DEWATERING

A. Perform dewatering in accordance with approved Shop Drawings. Keep the Engineer advised of any changes made to accommodate field conditions and, on completion of the dewatering system installation, revise and resubmit Shop Drawings as necessary to indicate the installed configuration.

B. Organize dewatering operations to lower the groundwater level in excavations as required for prosecution of the work, and to provide a stable, dry sub grade for the prosecution of construction operations. Prior to placement of concrete, the sub grade shall be in a firm, well-drained condition, and of adequate and uniform load-bearing nature to support construction personnel, construction materials, construction equipment, and steel reinforcing mats without tracking, rutting, heaving, or settlement. All weak, soft, saturated, or otherwise unsuitable material shall be removed and replaced with approved backfill.

C. Maintain water level at lower elevations, so that no damage to structures can occur because of buildup of excessive hydrostatic pressure, and provide for maintaining the water level a minimum of 2 feet below the sub grade.

D. Additional temporary lowering of the water table may be required to provide suitable soil conditions for the preparation of sub grades for footings and foundations. This may be accomplished by increased pumping from wells, installation of trench drains and sumps, or other appropriate methods.

E. The extent of dewatering may be reduced for structures designed to withstand hydrostatic uplift pressure, provided such water level does not result in uplift pressures in excess of 80 percent of the downward pressure produced by the weight of the structure and backfill in place. The extent of de-watering will be determined by the Contractor based on piezometer readings.

F. Maintain groundwater level a minimum of 2 feet below the prevailing level of backfill being placed.

G. The extent of dewatering for structures with a perforated undertrack drainage system may be reduced in the same manner as for units designed to withstand hydrostatic uplift pressure, provided means of draining the affected portion of the main track drainage systems, including adequate standby equipment, are furnished, installed, and removed, as required.

H. Methods of dewatering may include sump pumping, single or multiple stage well point systems, eductor and ejector type systems, deep wells, and combination thereof.

I. Locate dewatering facilities where they will not interfere with utilities and construction work to be performed by others.

J. Modify dewatering procedures that cause, or threaten to cause, excessive ground movement or damage to new or existing facilities, so as to prevent further ground movement damage.

K. Wherever possible groundwater shall be discharged into a nearby, existing storm sewerage or drainage system.

3.03 RECORDS

A. Observe and record the average flow rate and time of operation of each pump used in the dewatering system. Where necessary, provide appropriate devices, such as flow meters, for observing the flow rates. Submit flow-rate data during the period that the dewatering system is in operation.

B. Observe and record the elevation of the groundwater during the period that the dewatering system is in operation. Submit observation records within 24 hours of reading, on a regular basis.

C. During initial period of dewatering, make required observations on a daily basis. If, after a period, dewatering operations have stabilized, reduce observations to longer intervals as appropriate.

D. Submit water quality test results on a periodic basis as required by the jurisdictional authority.

3.04 RESTORATION

A. Restore existing structures to conditions equivalent to those existing prior to the start of work, including repair of any settlement-related damage.

B. Remove all equipment and instrumentation used for dewatering.

END OF SECTION 31 23 19

SECTION 31 23 25

CONTROLLED DENSITY FILL

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Portland cement.

B. Fly ash.

C. Air-entraining admixture.

D. Aggregate.

1.02 RELATED SECTIONS

A. Earthwork fill and backfill are specified in Section 31 00 00, Earthwork.

B. Backfill for utility trenches is specified in Section 33 05 28, Trenching and Backfilling for Utilities.

1.03 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for controlled density fill will be by the lump-sum method or by the unit-price method as determined by the listing of the bid item for control density fill indicated in the Bid Schedule of the Bid Form.

B. Lump Sum: If the Bid Schedule indicates a lump sum for controlled density fill, the lump-sum method of measurement and payment will be in accordance with Section 01 20 00, Price and Payment Procedures, Article 1.03.

C. Unit Price: If the Bid Schedule indicates a unit price for controlled density fill, the unit-price method of measurement and payment will be as follows:

1. Measurement: Except as specified otherwise in other Sections of these specifications or the Contract Specifications, control density fill will be measured for payment by the cubic yard, and quantities will be computed, based on the neat lines, section profiles, and dimensions indicated on the Contract Drawings.

2. Payment: Controlled density fill will be paid for at the indicated Contract unit prices for the computed quantities as determined by the measurement method specified in Article 1.03.C.1, herein.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM C33/C33M Standard Specification for Concrete Aggregates

2.	ASTM C94/C94M	Standard Specification for Ready-Mixed Concrete
3.	ASTM C150/C150M	Standard Specification for Portland Cement
4.	ASTM C231/C231M	Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
5.	ASTM C260/C260M	Standard Specification for Air-Entraining Admixtures for Concrete
6.	ASTM C618	Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete

1.05 DEFINITION

A. Controlled Density Fill (CDF) is a flowable mixture of aggregate and cementitious material containing sufficient portland cement to develop a 28-day compressive strength of 50 to 150 psi, that self compacts upon backfilling placement.

1.06 SUBMITTALS

A. General: Refer to Sections 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Mix Design: Submit controlled density fill mix design in accordance with applicable requirements of Section 03 05 15, Portland Cement Concrete.

C. Test Sample: Provide test sample in accordance with applicable requirements of ASTM C231/C231M.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Portland Cement: ASTM C150/C150M, Type I or Type II.

B. Fly Ash: ASTM C618, Class F. Fly ash shall not inhibit air entrainment.

C. Air-Entraining Admixture: ASTM C260/C260M.

D. Aggregate: ASTM C33/C33M, graded aggregate, maximum size of 3/8 inch.

E. Water: Potable.

2.02 MIX DESIGN

A. Requirements: Controlled density fill shall be composed of cementitious materials, aggregate, water, and an air-entraining admixture, as follows:

1. Cementitious materials shall be portland cement in combination with fly ash.

2. Admixture shall be an air-entraining agent.

B. Aggregate Content: CDF mixture shall contain no aggregate larger than 3/8 inch. Amount passing a No. 200 sieve shall not exceed 12 percent. Imported material in any combination, shall be free of organic material and other deleterious substances.

C. Air Content: Total calculated air content of the sample, prepared in accordance with ASTM C231/C231M, shall not exceed 30 percent.

D. Strength: Controlled density fill shall have an unconfined compressive strength at 28 days of 50 psi to a maximum of 150 psi.

PART 3 – EXECUTION

3.01 MIXING AND DELIVERY

A. Controlled density fill shall be batched at a ready mixed plant and shall be mixed and delivered to the work site by transit mixing trucks in accordance with ASTM C94/C94M.

3.02 INSTALLATION

A. Controlled density fill material shall be placed in the excavations and trenches to be backfilled to the indicated elevations in level layers. Do not perform any vibratory consolidation or compaction.

B. Equipment and traffic shall not be permitted on the controlled density fill until the surface of the CDF will withstand the weight of the equipment and traffic without displacement or damage.

C. Provide steel trench plates to span trenches where required to provide passage for vehicles and other equipment.

END OF SECTION 31 23 25

SECTION 31 35 00

SLOPE PROTECTION

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Slope paving

B. Channel paving

C. Crib walls

D. Riprap

E. Hydroseeding

1.02 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for slope protection will be either by the lump-sum method or by the unit-price method as determined by the listing of the bid item for slope protection indicated in the Bid Schedule of the Bid Form.

B. Lump Sum: If the Bid Schedule indicates a lump sum for slope protection, the lump-sum method of measurement and payment will be in accordance with Section 01 20 00, Price and Payment Procedures, Article 1.03.

C. Unit Price: If the Bid Schedule indicates a unit price for slope protection, the unit-price method of measurement and payment will be as follows:

1. Measurement:

   a. Concrete block, concrete paving, shotcrete, stone paving, and rock blanket type slope protection will be measured for payment by the square yard, including bedding material, concrete, mortar, and grout, complete in place.

   b. Aggregate sub base or base for slope protection will be measured for payment as specified in Section 32 11 17, Aggregate Sub Base Courses, or Section 32 11 23, Aggregate Base Courses.

   c. Earthwork necessary for construction of slope protection will be measured for payment as specified in Section 31 00 00, Earthwork.

   d. Crib-wall components will be measured for payment by the pound or by the ton, as appropriate, including wall construction complete in place.

   e. Riprap will be measured for payment by the ton, including filter aggregate, filter fabric, and placement of stones.

   f. Hydroseeding will be measured for payment by the square yard complete in place, including any required replacement or reseeding.

2. Payment: Slope protection will be paid for at the indicated Contract unit prices for the computed quantities as determined by the measurement method specified in Article 1.02.C.1.

1.03 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM C33/C33M Standard Specification for Concrete Aggregates
2. ASTM C91/C91M Standard Specification for Masonry Cement
3. ASTM C144/C144M Standard Specification for Aggregate for Masonry Mortar
4. ASTM C90 Standard Specification for Loadbearing Concrete Masonry Units
5. ASTM C150/C150M Standard Specification for Portland Cement
6. ASTM C270 Standard Specification for Mortar for Unit Masonry
7. ASTM C568/C568M Standard Specification for Limestone Dimension Stone
8. ASTM C615/C615M Standard Specification for Granite Dimension Stone
9. ASTM C915 Standard Specification for Precast Reinforced Concrete Crib Wall Members

B. State of California, Department of Transportation (Caltrans), Standard Specifications:

1. Section 21 Erosion Control
2. Section 53 Shotcrete
3. Section 96 Geosynthetics

1.04 SLOPE PROTECTION CLASSIFICATION

A. Block Paving: Precast concrete block units with mortar-filled or grouted joints.

B. Concrete Paving: Monolithic concrete paving.

C. Crib Wall: Earth-retaining structure constructed of interlocking, reinforced precast concrete crib-wall members; may be “open-faced” or “closed-face” type structure.

D. Hydroseeding: Slurry mixture of seed, wood fiber, fungicide, fertilizer, and water, applied to ground areas under pressure with hydraulic hydro-seeder equipment.

E. Riprap: Hard, durable, angular stone or rock placed to produce a well-graded mass of stone not less than 2-feet thick.

F. Shotcrete (Air-Blown Mortar): Mixed fine aggregate and portland cement pneumatically applied.

G. Stone Paving: Quarry stone laid in uniform courses with broken joints filled with mortar or grout.

H. Rock Blanket: Cobblestone laid in irregular courses set in concrete.

1.05 SITE CONDITIONS

A. Do not grout slope or channel paving or place concrete slope paving when the temperature falls below 50 degrees Fahrenheit. During cold weather, provide protective coverings for the work.

B. Should any work be exposed to temperature of 40 degrees Fahrenheit or below, within 4 days after grouting or concrete placement, cover the work with a 1-foot thick layer of straw, hay, or mulch; then cover with a weighted cover of canvas or plastic sheet.

PART 2 – PRODUCTS

2.01 MATERIALS FOR PAVING

A. Concrete Block Pavers: Precast concrete block units conforming to ASTM C90, 4 inches by 12 inches by 16 inches in size unless otherwise indicated.

B. Stone Pavers: Quarry stone of granite, limestone, or other similar durable stone; rectangular exposed surface with split or quarry face finish; uniform in color; 12 to 28 inches long, 10 to 14 inches wide, 4 to 6 inches thick, conforming with ASTM C568/C568M or ASTM C615/C615M as applicable.

C. Cobblestone: Cobblestone of granite, basalt, or other similar durable stone; exposed surface with smooth finish; uniform in color; 3 to 8 inches long, 5 to 12 inches wide, 2 to 4 inches thick.

D. Bedding Material: Clean and graded sand passing a No. 4 U.S. Standard sieve, conforming generally to ASTM C33/C33M, or masonry sand conforming to ASTM C144.

E. Mortar and Grout: Mortar or grout for filling of joints or voids between block and stone pavers shall be ASTM C270, Type M mortar using ASTM C91/C91M, Type M masonry cement or ASTM C150/C150M, Type I or II portland cement, and ASTM C144 aggregate. Adding of lime will not be permitted. Minimum strength at 28 days: 2,500 psi.

F. Concrete: Refer to Section 03 30 00, Cast-In-Place Concrete, Section 03 05 15, Portland Cement Concrete, and Section 03 35 00, Concrete Finishing, for requirements. Provide minimum Class 3000 concrete.

G. Shotcrete: Refer to Section 03 37 13, Shotcrete, and Caltrans Standard Specifications, Section 53, for requirements.

2.02 CRIB WALLS

A. Provide crib-wall units as indicated conforming to ASTM C915.

2.03 RIPRAP

A. Stone: Hard, durable, and angular in shape; resistant to weathering; and free from overburden, spoil, shale, and organic materials. Neither breadth nor thickness of a stone shall be less than one-third its length. Select stones insofar as practicable for size and shape, in order to secure large, flat-surfaced stones that produce a relatively true and even surface with a minimum of voids.

B. Gradation: Conform to the following approximate limits:

1. Percent of Total Weight:

Size of Stone	Percentage Limits
400 pounds or heavier	50 - 100
300 pounds	50 - 80
200 pounds	20 - 50
25 pounds	10 - 30

2. Maximum amount passing a 2-inch sieve: five percent.

C. Drainage and Filter Aggregates: Refer to Section 33 46 00, Sub drainage, for requirements.

D. Filter Fabric: Conform to requirements of Caltrans Standard Specifications, Section 96, for Geosynthetics.

2.04 HYDROSEEDING MATERIALS AND EQUIPMENT

A. Mulch:

1. Composition: Green-colored, fibrous, 100 percent virgin wood fiber mulch containing no growth or germination-inhibiting factors.

2. Dispersion in Slurry: Mulch shall be manufactured in such manner that, after addition to and agitation in slurry tanks with fertilizer, seed, water, and other approved additives, fibers in the material will become uniformly suspended to form a homogeneous slurry.

3. Absorption Capacity: When hydraulically sprayed on the ground, mulch shall form a blotter-like ground cover impregnated uniformly with seed which will allow the absorption of moisture and rainfall to percolate to the underlying soil.

4. Weight: Weight specifications of this material from suppliers, and for all applications, refers to air-dry weight of the fiber material. Absolute air dry weight is based on standards of the Technical Association of the Pulp and Paper Industry for wood cellulose and is considered equivalent to 10 percent moisture.

5. Labeling: Each package of cellulose fiber shall be marked by the manufacturer to show the air-dry weight content.

B. Seed: California native grasses and forbes mix as commercially available, mixed in the following proportions:

Festuca rubra/Molate Red Fescue – 16.6 lbs per acre/0.038 lbs per 1,000 sf

Agrostis pallens/Bentgrass – 16.6 lbs per acre/0.038 lbs per 1,000 sf

Stipa pulchra/Purple Needle Grass – 16.6 lbs per acre/0.038 lbs per 1,000 sf

Eschscholzia californica/California poppy – 0.50 lbs per acre/0.0012 lbs per 1,000 sf

Lupinus nanus/Sky Lupine – 0.50 lbs per acre/0.0012 lbs per 1,000 sf

C. Fertilizer: A complete fertilizer composed of natural organic material or derivatives, containing 16 percent nitrogen, 6 percent phosphoric acid, and 8 percent potash.

D. Water: Potable water. Furnish and transport as required.

E. Hydroseeding Slurry Mix: Mixture shall be composed of the following proportions for each 1,000 square feet of coverage:

1. Mulch 28 pounds
2. Seed 10 pounds
3. Fertilizer 11 pounds
4. Water 40-60 gallons

F. Hydroseeding Equipment:

1. Mixer: Commercial type hydro-seeder for application of slurry. Equipment shall have a built-in agitation system with an operating capacity sufficient to agitate, suspend, and homogeneously mix the slurry.

2. Distribution Lines: Large enough to prevent stoppage and to provide even distribution of slurry over the ground.

3. Pump Capacity: 150 psi at the nozzle.

4. Slurry Tank: Minimum capacity of 1,000 gallons, mounted on a traveling unit with the slurry tank and spray nozzles in proximity close enough to the areas to be seeded to provide uniform distribution without waste.

PART 3 – EXECUTION

3.01 SLOPE PAVING

A. Aggregate Base: Place concrete blocks, stone, or concrete over an approved compacted aggregate subbase or base in accordance with applicable requirements of Section 32 11 17, Aggregate Subbase Courses, or Section 32 11 23, Aggregate Base Courses.

B. Block Paving: Lay block pavers in minimum 2-inch thick sand bedding material, in uniform courses with joints not exceeding one inch in width. Securely bed pavers and then fill joints with mortar or grout to the top of the paved surface. Minimum thickness or depth of mortar joints: 2 inches. Cover completed paving and keep wet for a minimum period of 5 days.

C. Stone Paving: Comply with requirements specified above for block paving, except that stone paving shall have broken joints not exceeding two inches in width. Where necessary, chink interstices with smaller stones. Fill joints with mortar or grout to top of paved surface.

D. Rock blanket: Excavate areas to receive rock blanket to the depth shown after clearing. Where rock blanket is to be placed adjacent to existing curbs, dikes, pavement, sidewalks or walls, excavate so that the finished rock blanket elevation adjacent to those items will maintain the planned flow lines, slope gradients, and contours of the job site. After excavation, grade subgrade to receive rock blanket to a smooth, uniform surface, and compact to not less than 90 percent relative compaction. Place concrete to a minimum thickness of 4 inches. Rock must be placed while concrete is still plastic. Space rocks a maximum of 1/2 inch apart. Rocks must have a 1-inch maximum separation between the top of adjacent rock surfaces. Remove concrete adhering to the exposed surfaces of the rock by approved methods. Loose rocks, or rocks with a gap greater than 3/8 inch, must be reset by methods accepted by the Engineer. The rock gap is measured from the edge of the rock to the surrounding concrete bedding. Place mortar as directed by Engineer.

E. Concrete Paving: Comply with applicable requirements of Section 03 30 00, Cast-In-Place Concrete, and Section 03 35 00, Concrete Finishing. Provide minimum 4-inch thick concrete. Provide coarse “broom finish” and curing as specified in Section 03 35 00, Concrete Finishing.

F. Shotcrete: Comply with applicable requirements of Section 03 37 13, Shotcrete, and Caltrans Standard Specifications, Section 53.

3.02 CHANNEL PAVING

A. Comply with requirements specified above for slope paving.

3.03 CRIB WALLS

A. Provide crib-wall construction as indicated and in accordance with applicable requirements of ASTM C915. Crib-wall construction shall be “open-faced” or “closed-face” as indicated or appropriate for the soil conditions. Provide wall surface that is approximately parallel to, and within 6 inches of, the slope indicated.

3.04 RIPRAP

A. Place filter aggregate and filter fabric on prepared slope or area in such a manner as to produce a well-graded surface, then place mass riprap stone with minimum practicable percentage of voids and a minimum thickness of 24 inches. Place stone to its full course thickness in one operation and in such a manner as to avoid displacing the underlying material. Placing of stone in layers or by dumping into chutes or by similar methods likely to cause segregation will not be permitted. Place and rearrange stones by hand or by mechanical equipment as necessary to produce a compact riprap protection in which all sizes of stones are placed in their proper proportions.

B. Place riprap in conjunction with the construction of the embankment with only sufficient lag in construction of the riprap protection to allow for proper construction of the embankment and to prevent mixture of embankment and riprap material. Maintain elevation of riprap to within five feet of elevation of embankment during construction.

3.05 HYDROSEEDING

A. Examination:

1. Verify that areas to receive hydroseeding are clear of stones larger than one and one half inches in diameter, weeds, debris, and other extraneous materials.

2. Verify that grades are within 1 inch, plus or minus, of the required finished grades.

3. Verify that topsoil is in proper planting condition to receive and accept hydroseed slurry.

B. Preparation: Apply water, as necessary, to bring soil to optimum moisture content for planting.

C. Slurry Mixing:

1. Perform slurry preparation at the site.

2. Add water to tank when engine is at half throttle. When water level has reached height of agitator shaft, establish proper circulation and add seed.

3. Do not permit seed to remain more than 30 minutes in the slurry.

4. Add fertilizer, followed by mulch. Mulch shall be added to the mixture after the seed, and when the tank is at least one-third filled with water.

5. Open engine throttle to full speed when tank is half-filled with water. Add all mulch by the time tank is two-thirds to three-quarters full. Commence spraying immediately when tank is full.

D. Application:

1. Apply slurry mix in a sweeping motion to form a uniform mat at the specified rate. Keep hydroseeding within designated areas and keep from contact with other plant materials.

2. Slurry mixture that has not been applied within 4 hours of mixing shall be discarded. Promptly remove from the site.

E. Reseeding: Reseed areas and parts of areas which fail to show a uniform stand of grass after 21 days, until all areas are covered with a satisfactory stand of grass.

F. Cleanup and Protection:

1. Wash off slurry overspray from other plant materials, planting areas, and paved areas.

2. Do not operate any equipment over hydroseeded areas.

G. Establishment of Hydroseed:

1. The work includes a grass-establishment period of 30 calendar days, commencing immediately after completion and acceptance of the initial hydroseeding application.

2. If, during the establishment period, areas are lacking in sufficient grass seeding to assure an adequate stand of grass, such areas shall be recultivated and reseeded within 24 hours after written notification from the Engineer.

3. The establishment period, in this case, shall be continued until the work meets specified requirements.

4. The establishment period shall include continuous operation of watering, weeding, mowing, fertilizing, spraying, insect and pest control, and any other normal operation required to assure proper growth.

END OF SECTION 31 35 00

SECTION 31 40 00

SHORING AND UNDERPINNING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Detection of movement

B. Shoring and underpinning

C. Concrete piers, walls, and pile caps

D. Piles and caissons

E. Load testing of piles and acceptance criteria

F. Fill and backfill

G. Temporary supports

H. Restoration

1.02 RELATED SECTIONS

A. Section 31 23 19, Dewatering

B. Section 31 50 00, Excavation Support and Protection

C. Section 31 62 00, Driven Piles

D. Section 31 63 29, Drilled Concrete Piers and Shafts

E. Section 31 00 00, Earthwork

1.03 MEASUREMENT AND PAYMENT

A. Measurement: Shoring and Underpinning will be measured for payment by the lump-sum method, acceptably constructed and completed.

B. Payment: Shoring and Underpinning will be paid for at the indicated Contract lump-sum price, as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. State of California, Department of Transportation (Caltrans), Office of Structure Construction:

1. Trenching and Shoring Manual

B. American Society of Civil Engineers (ASCE):

1. ASCE 37 Design Loads on Structures during Construction

1.05 DEFINITIONS

A. Shoring: Props or posts of timber or other material in compression or bending, used for temporary support of excavations, formwork, or unsafe structures.

B. Sheeting: A line of timber or planks, plain or tongue-and-grooved on sides, driven endwise into the ground to protect subgrade operations.

C. Underpinning: Permanent construction, as indicated, which directly transmits existing structure foundation loads to a lower bearing elevation or strata, and which preserves the structures being underpinned.

D. Support: Facilities required to prevent movement of existing structures until the completion of the underpinning.

E. Lagging: A temporary or permanent excavation support structure consisting of heavy timber boards, planking, or sheathing secured in place by steel H-piles.

F. Restoration: Reconstruction by repair or replacement of portions of structures removed or altered by underpinning and support operations.

G. Parcel: An area as indicated, including the structures thereon, and any vaults and permanent closure walls connected thereto.

1.06 SUBMITTALS

A. Requirements: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures. Shop Drawings and supporting calculations for shoring and underpinning shall be submitted to the Engineer for review and approval.

B. Excavating, Shoring, and Underpinning Program: Prepare and submit a written schedule and procedure, along with detailed drawings, of the proposed excavations, shoring, and underpinning work to the Engineer for review.

C. Shop Drawings: Submit Shop Drawings, indicating method, staging, and necessary details for construction of underpinning and support for each structure on which work is to be performed. Show details of shop assemblies when required for restoration of structures. Shop Drawings and calculations shall be prepared, sealed, and signed by a professional civil or structural engineer currently registered in the State of California.

D. Calculations: Submit design analyses and calculations to support Shop Drawings.

E. Procedures:

1. Submit procedure for detection of movement, as specified in Article 3.01 herein.

2. Submit procedure for preloading (jacking load) new foundations.

3. Submit procedure for proof load testing and preloading (jacking load) of lateral support systems, such as strut and tieback assemblies.

F. Jacking Gage Calibration: Submit data for the pressure gage and jack combinations certified by an accepted testing laboratory not earlier than 14 days prior to start of use for underpinning.

G. Restoration: Submit procedures, methods, and materials lists for restoration of structures and facilities.

1.07 REGULATORY REQUIREMENTS

A. Regulatory requirements that govern the work of this Section include the following governing codes:

1. California Code of Regulations, Title 8, Division 1, Chapter 4, Subchapter 4 — Construction Safety Orders.

2. California Code of Regulations, Title 24, Part 2, California Building Code, Chapter 33 Safeguards During Construction, and Structural Design Chapters 16 and 16A.

a. Excavations shall be defined or classified as being in excess of 12 feet in depth below grade, and, as such, shall comply fully with the requirements of Section 3304.1 of the California Building Code.

b. Contrary to certain provisions of the California Building Code, extensions of foundations, if any, regardless of depth, shall be at the expense of the Contractor, and the Contractor shall make provisions for such expense.

1.08 SITE CONDITIONS

A. Access: In cases where parcels are not available upon Notice to Proceed, parcels will be available as indicated in the Contract Specifications. Notify the Engineer at least 30 Days in advance of the date on which the Contractor requires occupancy of parcels to be underpinned, supported, and restored.

B. Staging and Working Space: Working areas for underpinning and support are shown on the Contract Drawings. If additional working areas beyond those obtained by the District are necessary, obtain use of such areas at no additional expense to the District.

C. Permits: The District will obtain and pay for permits for entry into structures and for the right to perform underpinning, support, and restoration as indicated. The Contractor shall obtain and pay for all other permits, give all notices required, and make all other arrangements necessary.

D. Temporary Partitions: Where indicated or required, build closed temporary partitions of suitable materials to isolate the work site from the portions of the structure not occupied by the Contractor.

E. Maintenance of Services: Locate, protect, support, and maintain uninterrupted all utilities, equipment, services, and owner's and tenant’s chattels within the limits of the underpinning work, or relocate same as indicated or required.

PART 2 – PRODUCTS

2.01 MATERIALS AND EQUIPMENT

A. Requirements: The Contractor shall furnish all materials, tools, equipment, facilities, and services as required for providing the necessary shoring and underpinning work and facilities. Jacks and jacking equipment shall be more than adequate for the imposed loads and shall be provided with calibrated gages.

B. Shoring and Bracing Materials: Provide heavy timber posts, beams, planks, boards, pipe struts, pin piles, and accessories as required.

C. Lagging and Sheeting Material: Provide heavy timber boards, planking, or sheathing as required. Lagging boards shall be secured in place by steel H-piles, with boards inserted between the H-flanges.

D. Piles and Caissons: Refer to Sections 31 62 00, Driven Piles, and 31 63 29, Drilled Concrete Piers and Shafts, for requirements. Provide piles and caissons as indicated.

1. Underpinning Pier: As defined, an excavated pit, provided generally by manual excavation, which is carried to a pre-selected bearing surface and then filled with concrete to provide supplementary foundation support for the underpinned structure.

E. Concrete: Refer to Sections 03 11 00, Concrete Forming, 03 20 00, Concrete Reinforcing, 03 30 00, Cast-In-Place Concrete, and 03 05 15, Portland Cement Concrete, for requirements. Concrete shall be regular concrete weighing not less than 145 pounds per cubic foot, with a minimum compressive strength at 28 days of 4,000 psi.

F. Shotcrete: Refer to Section 03 37 13, Shotcrete, for requirements.

G. Grout: Refer to Section 03 61 11, Non-Shrink Grout, for requirements.

H. Structural Steel: Refer to Sections 05 12 00, Structural Steel Framing, and 05 50 00, Metal Fabrications, for requirements.

PART 3 – EXECUTION

3.01 DETECTION OF MOVEMENT

A. Refer to requirements of Specification Section 31 50 00, Excavation Support and Protection.

3.02 SHORING AND UNDERPINNING

A. Existing footings, foundations, pile caps, grade beams, retaining walls, and pavement that may be affected by excavation operations shall be shored or underpinned adequately or otherwise protected against settlement and shall be protected against lateral movement. The design loads shall include not only lateral soil pressure but also wind and seismic loadings from soil and structure being protected. The design shall be submitted for Engineer's approval.

B. Provide soldier piling, lagging and sheeting, tie-backs, slurry diaphragm wall, and cementitious grouting, as required, to hold back earth at excavations and as required to prevent cave-ins and earth sloughs.

C. Footings, foundations, pile caps, grade beams, retaining walls, or pavements which have been undermined by earthwork and pile-driving operations shall be filled and supported with concrete extended to undisturbed bearing earth or bedrock.

D. Concrete may be placed as a stiff mix of minimum slump (dry pack), or concrete may be pneumatically placed (shotcrete), or concrete may be placed by conventional methods with concrete formed to hold it in proper position.

3.03 CONCRETE PIERS, WALLS, AND PILE CAPS

A. Install concrete underpinning piers, walls, and pile caps as indicated, with the bottom at the indicated or bearing elevation and the top approximately three inches below the structure to be underpinned. Dry pack the space within three days after concrete placement is completed.

B. Where earth forms are indicated, install waterproof building paper or board between the earth and concrete to prevent water loss from the fresh concrete.

C. Do not remove support of existing structure until concrete piers, walls, or pile caps have attained design strength.

3.04 PILES AND CAISSONS

A. Install pipe pile shells or drilled shafts at locations indicated, and extend from underside of existing footings to indicated elevations, plus additional penetration if required to develop the design working load of the pile or caisson. Drilled shafts shall conform with requirements of Section 31 63 29, Drilled Concrete Piers and Shafts.

B. Distribute jacking reactions over the existing structure in a manner that will not overstress or deflect the existing structure.

C. Weld splices where indicated. Provide watertight welds capable of developing the full strength of the pile or caisson. Align splices to ensure the straightness of the pile from top to tip. Use outside sleeves and backup rings as necessary.

D. Where the pile tip is below the ground-water table, maintain the elevation of the water inside the shell at approximately the elevation of the ground-water table during installation of the shell.

E. After installation of the shell, apply the full design-working load to the empty pile shell and maintain until there is no measurable settlement over a one hour period.

F. Maintain the excavation within the pile shell approximately 12 inches above the tip during driving, and dewater pile shells prior to filling with concrete in a manner which will prevent loss of earth or soil at the tip. An earth plug may be left in the pile tip or a concrete plug may be placed and cured prior to dewatering pile shells.

G. After load testing to the design load, dewatering, and inspection of the shell by the Engineer, fill accepted pile shells with concrete in the presence of the Engineer. Keep an accurate record of the volume of concrete deposited in each pile. Deficiencies revealed by comparing the volume of the inside of the pile with the volume of placed concrete will be cause for rejection of the pile or correction of the deficiency.

H. Securely wedge in place with steel wedges those piles that have satisfied the load-testing requirements. Weld and encase in concrete all wedges, plates, wedging struts, and piles, as indicated or required.

I. Following completion of load transfer of underpinned structures, fill the underpinning pits with concrete as indicated. Provide reinforcement, shear keys, dowels, and waterstops as indicated or required. Place concrete to within 3 inches of the underside of the existing foundation. After three days, dry pack the space between the foundation and concrete.

3.05 LOAD TESTING OF PILES AND ACCEPTANCE CRITERIA

A. After the concrete within the pile or shaft has set for at least 24 hours, test each pile or pier by jacking to a load equal to 150 percent of the design-working load of the pile. Maintain the load until there is no measurable settlement of the pile over a one-hour period.

B. Load-test piles in sequences and groupings that will minimize or eliminate eccentric loadings on the existing foundation and piles.

C. Piles will be rejected and shall be retested if, in the opinion of the Engineer, there is a danger of unequal loading.

D. Should the existing structure fail to furnish sufficient reaction to installed underpinning piles to the test loads specified, provide additional reaction to prevent damage to, and movement of, the structure during installation of piles, and to obtain specified underpinning test loads. The additional reaction shall not detrimentally affect the structure.

E. Maximum out-of-plumb tolerance for installed piles: two percent.

F. Maximum offset of top of pile from the design center: 3 inches.

3.06 FILL AND BACKFILL

A. Provide engineered fill and backfill in accordance with applicable requirements of Section 31 00 00, Earthwork, after acceptance of the underpinning by the Engineer.

3.07 TEMPORARY SUPPORTS

A. Install temporary supports where necessary to support structures to be underpinned and those that will be affected by underpinning and restoration work.

3.08 RESTORATION

A. Restore existing structures to conditions equivalent to those existing prior to the start of shoring and underpinning work, including repair of any settlement-related damage.

END OF SECTION 31 40 00

SECTION 31 50 00

EXCAVATION SUPPORT AND PROTECTION

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Detection of movement

B. Soldier piles and lagging

C. Sheet piling

D. Slurry walls

E. Bracing and tiebacks

F. Soil anchors

G. Soil nailing

H. Secant walls

I. Soil mix walls

J. Removal of excavation support systems

K. Restoration

1.02 RELATED SECTIONS

A. Shoring and underpinning for safeguarding structures are specified in Section 31 40 00, Shoring and Underpinning.

B. Instrumentation for monitoring earth and structure movements, as well as subsurface water levels, is specified in Section 31 09 00, Geotechnical Instrumentation and Monitoring of Earthwork.

C. Excavation and other earthwork operations are specified in Section 31 00 00, Earthwork.

D. Trenching for utilities is specified in Section 33 05 28, Trenching and Backfilling for Utilities.

E. Coordinate the work of this Section with the work of Section 31 23 19, Dewatering, and Section 31 40 00, Shoring and Underpinning.

1.03 MEASUREMENT AND PAYMENT

A. Measurement: Excavation Support Systems will be measured for payment by the lump-sum method, acceptably constructed, maintained, and removed.

B. Payment: Excavation Support Systems will be paid for at the Contract lump-sum price, as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. American Society of Civil Engineers (ASCE):

1. ASCE 37 Design Loads on Structures during Construction

B. American Society for Testing and Materials (ASTM):

1. ASTM A36 Specification for Structural Steel
2. ASTM A328 Specification for Steel Sheet Piling
3. ASTM A416 Standard Specification for Low-Relaxation, Seven-Wire Steel Strand for Prestressed Concrete
4. ASTM A563 Specification for Carbon and Alloy Steel Nuts
5. ASTM A586 Standard Specification for Metallic-Coated Parallel and Helical Steel Wire Structural Strand
6. ASTM A615 Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
7. ASTM A690 Standard Specification for High-Strength Low-Alloy Nickel, Copper, Phosphorus Steel H-Piles and Sheet Piling with Atmospheric Corrosion Resistance for Use in Marine Environments
8. ASTM A722 Standard Specification for High-Strength Steel Bar for Prestressing Concrete
9. ASTM C150 Specification for Portland Cement
10. ASTM C33 Specification for Concrete Aggregates
11. ASTM F432 Specification for Roof and Rock Bolts and Accessories
12. ASTM F436 Specification for Hardened Steel Washers

C. American Wood Preservers' Association (AWPA):

1. AWPA C3 Specification for Below Grade Preservative Treatment for Wood

D. State of California, Department of Transportation (Caltrans), Office of Structure Construction, “Trenching and Shoring” Manual.

E. Post Tensioning Institute (PTI): Post-Tensioning Manual, Chapter 4, Recommendations for Prestressed Rock and Soil Anchors

1.05 DEFINITIONS

A. Drainage Mat or Matting: A manufactured drainage material which is available in sheets or rolls and which may be used in excavation support systems to prevent buildup of hydrostatic pressure.

B. Lagging: A temporary or permanent excavation support structure consisting of heavy timber boards, planking, sheathing, or reinforced precast concrete planks secured in place by steel H-piles.

C. Proof Load: An applied load 25 percent greater than the design load, imposed by load test.

D. Secant Wall: An excavation support system consisting of a series of drilled, spaced soldier piles and intersecting, unreinforced concrete drilled piers or drilled shafts arranged in an arched configuration, filled with a lean concrete-mix cement and sand grout.

E. Sheeting: A line of timber or planks, plain or tongue-and-grooved on sides, driven endwise into the ground to protect sub grade operations.

F. Sheet Piling: Interlocking steel sheet piling installed vertically to hold back earth or retain soil and to keep water out of a foundation excavation. May be a temporary or permanent structure.

G. Shores/Shoring: Props or posts of timber or other material in compression, used for temporary support of excavations.

H. Slurry Wall: A reinforced concrete wall constructed by filling a trench with tremie concrete. Tremie concrete displaces the bentonite slurry already in the trench, forming a concrete barrier, when set, which retains the earth or soil on the exterior side of the slurry wall, and permits excavation and removal of the soil on the interior side of the wall.

I. Soil Anchor: A pre-stressed frictional anchorage device, consisting of a high-strength steel tendon, fitted with a stressing anchor at one end and an anchor device, permitting force transfer to the soil, at the other end, installed in a prepared hole that is drilled or driven into the ground.

J. Soil Mix Wall: A multiple-augered, cement-grout reinforced earth technique, incorporating steel H-beam reinforcement, whereby existing soils are mixed in place with cement grout, forming a row of overlapped soil cement columns, creating a reinforced earth wall excavation support system.

K. Soil Nailing: A soil reinforcement technique whereby an in-situ retaining structure is constructed by making successive excavations using driven or grouted reinforcing bars (or nails) to support the soil. Soil nailing does not require pre-stressing. Soil nailing requires simultaneous application of shotcrete to retain the excavated wall facing.

L. Soldier Piles: Vertical steel H-piles installed to take the side thrust of horizontal lagging. Also called soldier beams.

M. Strut: A brace or supporting member which resists thrusts in the direction of its own length; may be vertical, diagonal, or horizontal.

N. Tie-Backs: An excavation-face support obtained by grouted steel bars, wire strands, or tendons, with or without a dead-man, in combination with face-retaining or bearing steel plates, board timbers, or shotcrete reinforcement.

O. Tremie Concrete: Concrete placed by means of tremie equipment, for depositing concrete under water and thereby displacing bentonite slurry in a slurry-wall trench or excavation.

P. Waler: A horizontal beam used to brace or support vertical sheeting or sheet piling.

1.06 DESIGN CRITERIA

A. Basic unit stresses for the working stress design of excavation support structures shall be taken from the following references:

1. Structural Steel: Manual of Steel Construction, American Institute of Steel Construction (AISC).

2. Reinforced Concrete: Building Code Requirements for Structural Concrete, American Concrete Institute, (ACI 318).

3. Timber: California Building Code.

B. Design excavation support systems to support earth pressures, utility loads, equipment, applicable traffic and construction loads, and other surcharge loads in a manner which will allow the safe and expeditious construction of permanent structures without movement or settlement of the ground and in a manner which will prevent settlement of and damage to, or movement of, adjacent buildings, structures, utilities, or other facilities during the various stages of construction. Include evaluation of the effects of dewatering and flooding of excavation.

C. Design each component to support the maximum loads that may occur during various stages of construction. Include lateral pressure due to earthquake. For the purpose of this Section, the design load means the maximum load the support member will have to carry in actual practice, and the proof load means a specified test load greater than the design load. Shoring is required for excavations in the zone of influence. Zone of influence is defined here in Section 3.01. Seismic and wind loads shall be included in the shoring design. The soil and inertia lateral seismic design loads shall be determined by geotechnical engineer based on the specific site

seismicity. For temporary structures with an expected duration of less than five years, the site seismicity shall be based on a probabilistic ground motion with ten percent probability of exceedance in ten years and shall not be less than 0.1g. For temporary structures with an expected duration of over five years, the seismic loading for permanent retaining structures shall be used. For structures to be shored for 180 Days or less, wind loads and design shall be in accordance with ASCE/SEI 37. For structures to be shored for over 180 Days, wind loads and design shall be in accordance with applicable codes for permanent structures. Shoring shall be required to maintain at-rest soil condition and monitored for movement.

D. Support of excavation structures shall be analyzed for all conditions which may occur during the various stages of construction. Among others, these conditions include: installation, relocation and removal of struts; flooding and dewatering of excavations; and concreting of excavation bottom. The loading conditions on opposite sides of a cut may not be equal. In this case, both sides shall be designed for and be compatible with the larger loading. The conditions to which the design applies shall be indicated on the Shop Drawings.

E. Carry the bottom of support system to a depth below the main excavation as adequate to prevent lateral and vertical movement. Where additional excavation is carried below the main excavation, provide means to prevent movement of the main excavation supports.

F. Design the excavation support system to allow the required free excavated space for workers, concrete formwork, wall waterproofing, and drainage systems.

G. Design excavation support systems for staged installation and removal to conform to construction and backfill sequences as indicated. Leave excavation support systems in place, except as specified otherwise herein or in the Contract Specifications.

H. Employ walers, struts, and tieback anchors for horizontal support as required for excavation faces to be retained by soldier piles and lagging, sheet piles, or by concrete slurry walls. Provide struts with intermediate vertical and horizontal supports as required to prevent buckling. Struts shall be preloaded by wedging or jacking to 50 percent of the design load.

I. Provide diagonal bracing where needed for stability of the system. Use timber lagging, steel sheeting, or reinforced precast concrete sheeting or planking. Tiebacks and soil anchors will not be permitted to extend outside of the BART right-of-way property limits, unless the Contractor has obtained written (notarized) permission from adjacent property owners to use their properties for such purposes.

J. Design piles or other vertical support members to be incorporated in a system employing tiebacks or soil anchors to have the capability of resisting vertical components of tieback loads without significant settlement during any stage of excavation and construction.

K. Timber support systems, except lagging, shall be employed only for utilities and minor structures. Timber supporting members and lagging to be left in place shall be pressure-treated with wood preservative.

L. Where lagging is employed, the Contractor shall design the lagging to safely support the indicated loads. Minimum thickness of lagging between soldier piles spaced up to 7 feet on center shall be 3 inches for excavations of depth up to 25 feet, and 4 inches for excavations of depth in excess of 25 feet.

M. Soil-nailed walls may be used where soil conditions are appropriate. Shotcrete facing is required for all soil-nailed walls. Include vertical strips of drainage matting before shotcreting to assure proper drainage.

N. Provisions shall be made to protect struts from excessive deformations and stress variations induced by temperature fluctuations.

O. In reviewing submittals, the Engineer will use the criteria and loads for structures indicated on the Contract Drawings. The conditions to which the design applies shall be indicated on the Shop Drawings.

1.07 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data and Samples, for submittal requirements and procedures. Shop Drawings and supporting calculations for excavation support systems shall be submitted to the Engineer for review and approval.

B. Pre-construction Surveys: Submit pre-construction surveys as specified in Article 1.08 A. herein.

C. Movement Detection Procedures: Submit procedures for detection of movement as specified in Article 3.01 herein.

D. Excavation Support Systems Program:

1. Prepare and submit a written schedule and procedure, along with detailed drawings, of the proposed excavations and excavation support systems.

2. Include installation procedures; method of concrete placement; excavation sequence; interface details; protection measures for existing structures and facilities; instrumentation and monitoring procedures to check performance, sequence, and method of removal; and contingency plans for excessive wall or foundation movements.

3. The program shall take into account that excavations cannot extend beyond the BART right-of-way into adjacent properties above or below grade, unless otherwise indicated. Where tie-backs, soil anchors, soil nailing or similar support systems are required, the Contractor shall be solely responsible for securing permission from adjacent property owners to install such temporary and permanent systems. If the Contractor is unable to secure such permission, support systems shall be installed completely within the BART right-of-way.

a. Any such permission from adjacent property owners shall be in writing, and the owner's signature, granting such permission, shall be witnessed and properly notarized. Certified copies of all such permissions shall be submitted to the Engineer for record purposes.

E. Shop Drawings: Submit Shop Drawings and specifications for support systems, lagging, tie-back anchors, and internal bracing. Include the following:

1. Specific description of field quality control measures.

2. Details of interface with permanent structures.

3. Detailed description of tie-back soil anchors, soil nailing, and wales, if used, and the proposed installation procedure, including method of grouting anchors, grout type, and mix proportions.

4. Details of bracing struts and wales, if used, and the proposed installation procedures, including method and sequence of preloading.

5. Details of required preloading systems, pre-stressing systems, load measuring facilities, systematic schedule of preloading and pre-stressing operations, and sequence of construction.

6. Method and details for securing lagging in support system openings.

7. Proposed method of providing for utility penetrations.

8. Assembly and erection details of members and connections for the system.

F. Calculations: Submit appropriate design calculations to support Shop Drawings. Include maximum theoretical deflections of supporting members. Include calculations indicating the expected magnitude of vertical and lateral movement.

G. Professional Engineer’s Certification: The excavation support systems program, Shop Drawings, calculations, and test reports shall be prepared, sealed, and signed by a professional civil or structural engineer currently registered in the State of California. The Contractor shall select an engineer with experience in the design and construction of excavations and excavation support systems and shall submit the selected engineer's resume demonstrating such experience.

1. Where Caltrans approval for excavation support or shoring is required, submit check calculations and related documents prepared, signed, and sealed by an independent civil or structural engineer currently registered in the State of California. The check documents shall confirm the essential elements of the design and shall be prepared in accordance with the Caltrans Trenching and Shoring Manual.

H. Calibration Charts: Submit certified calibration charts for each jack-gage unit used for preloading.

I. Test Reports: Submit reports of performance tests and proof loading tests of soil anchors, certified by a professional civil or structural engineer currently registered in the State of California.

1.08 REGULATORY REQUIREMENTS

A. Regulatory requirements that govern the work of this Section include the following governing codes:

1. California Code of Regulations, Title 8, Chapter 4, Subchapter 4 — Construction Safety Orders.

2. California Code of Regulations, Title 24, Part 2, California Building Code, Chapter 33 and Appendix Chapter 33, and Structural Chapters 18 and 18A.

   a. Excavations, regardless of depth, shall comply fully with the requirements of Sections 3301.2, 3301.2a, and 3301.3 of the California Building Code.

1.09 SITE CONDITIONS

A. Pre-construction Surveys: The Contractor shall submit to the Engineer, for review and approval, pre-construction surveys for existing structures and facilities located above or adjacent to the new construction and which may be affected by the work. These surveys shall include photographs, maps, plans, written descriptions, and surveyed foundation levels as necessary to fully document pre-construction conditions.

B. Provision for Contingencies:

1. Monitor performance of components of excavation support systems, both for vertical and horizontal movement, at regular intervals. Provide strut-monitoring devices, installed in accordance with the manufacturer’s instructions, at locations indicated or required.

2. Provide and secure approval for a contingency plan, or alternative procedures, to be implemented in the event of an unfavorable performance of the system.

3. Have materials and equipment available to implement the approved contingency plan.

C. Existing Utilities:

1. Proceed with caution in areas of utility facilities and structures. Expose existing utilities by hand-excavation or by other methods acceptable to the utility owner’.

2. If existing utility facilities and structures interfere with proposed method of excavation support, modify or relocate such facilities in accordance with the utility owner's recommendations.

D. Loads: Lateral loads shall not be transferred to new concrete structures by removal of excavation support systems until the new structure has attained its 28-day compressive strength, or except as otherwise indicated.

PART 2 – PRODUCTS

2.01 EQUIPMENT AND FACILITIES

A. The Contractor shall furnish all tools, equipment, devices, appurtenances, facilities, and services for the construction and removal of excavation support systems as indicated or required.

2.02 MATERIALS

A. General: Materials for excavation support systems may be new or used, provided they are sound and free from strength-impairing defects.

B. Soldier Piles/H-Piles: ASTM A690 or ASTM A36 shapes of sizes indicated on approved Shop Drawings. Provide soldier piles or H-piles of sizes required to contain lagging, sheeting, or planking as indicated.

C. Steel Sheet Piling: ASTM A328, continuous interlocking type, of sizes indicated on approved Shop Drawings, with suitable handling holes.

D. Timber: Structural grade lumber with a minimum fiber stress in bending of 1100 psi.

1. Lagging: Heavy timber boards or planking of sizes indicated on approved Shop Drawings. Lagging boards or planking shall be secured and contained in place by H-piles (soldier piles), with boards inserted in the recesses between the H-flanges.

2. Posts, Struts, and Walers: Heavy timber posts, beams, stringers, and planking, as required, of sizes indicated on Shop Drawings.

3. Preservative Treatment: Wood members required to be left permanently in place shall be pressure-treated with preservative material in accordance with AWPA C3.

E. Concrete: Refer to Section 03 11 00, Concrete Forming, Section 03 20 00, Concrete Reinforcing, Section 03 30 00, Cast-In-Place Concrete, and Section 03 05 15, Portland Cement Concrete, for requirements. Provide Class 4000 concrete with a minimum cement content of 6.5 sacks per cubic yard unless otherwise indicated. Lean concrete, where indicated, shall conform to requirements of Section 03 05 15, Portland Cement Concrete.

F. Shotcrete: Refer to Section 03 37 13, Shotcrete, for requirements.

G. Tremie Concrete for Slurry Walls: Class 4000 concrete with coarse aggregate of one-inch maximum size (ASTM C33 size No. 57). Slump at placement: 5 to 6 inches, plus or minus one inch.

H. Bentonite Slurry: Natural Wyoming type granular bentonite, graded so that 90 percent will pass a 20 mesh sieve and less than 10 percent will pass a 200 mesh sieve, mixed with water. Bentonite slurry shall be a stable suspension of powdered bentonite with a minimum density of 65 pcf and a maximum density of 85 pcf.

I. Tiebacks:

1. Steel Bars or Rods: ASTM A615, Grade 60, threaded steel bars or bars conforming to requirements of ASTM A722 or ASTM F432, as applicable of sizes indicated on approved Shop Drawings. Provide complete with header or face plates conforming to ASTM A36 where required, nuts conforming to ASTM A563, and washers conforming to ASTM F436, as indicated or required.

2. Wire Strands: Single-strand or multiple-strand galvanized steel wire conforming to ASTM A416 or ASTM A586, as appropriate.

3. Grout: Pumpable concrete, with minimum compressive strength at 28 days of 4,000 psi. Concrete mix shall contain 6.5, 94-pound sacks of cement per cubic yard minimum. Aggregate size shall be commensurate with the space being filled. Comply with requirements of Section 03 05 15, Portland Cement Concrete, as applicable.

2.03 SOIL ANCHORS

A. Product Standards: Comply with applicable requirements of PTI Post-Tensioning Manual, Chapter 4, Article 4.5, Soil Anchors. Provide soil anchors complete with stressing anchorage and bearing plates, sheathing and pre-stressing steel, grout and grout tube (if required), and the required drilling equipment.

B. Bars: ASTM A722 deformed pre-stress threadbars, with a minimum ultimate tensile strength of 150 ksi.

C. Wire Strand: ASTM A416, Grade 270, low relaxation, seven-wire stress-relieved strand, with ultimate tensile strength of 270 ksi.

D. Anchorage Grout: Portland cement, aggregate, water, and a manufactured non-corrosive expansive admixture, of suitable aggregate size and consistency for pressure grouting. Grout shall develop a minimum compressive strength at 28 days of 4,000 psi. The Contractor may substitute a high-strength, non-shrink, nonmetallic cementitious grout conforming to applicable requirements of Section 03 61 11, Non-Shrink Grout.

2.04 SOIL NAILING

A. Steel Bars: ASTM A615, Grade 60, threaded, deformed steel bars of sizes indicated on approved Shop Drawings. Provide complete with steel face plates, nuts, and washers as specified herein for tiebacks. Steel face plates shall engage the shotcrete reinforcement.

B. Shotcrete: Comply with applicable requirements of Section 03 37 13, Shotcrete.

C. Drainage Matting: Comply with applicable requirements of Section 33 46 00, Subdrainage, for the preformed permeable drainage liner.

D. Concrete Reinforcement: Reinforcing steel bars (rebar) and welded wire fabric shall comply with applicable requirements of Section 03 20 00, Concrete Reinforcing.

2.05 SECANT WALL SYSTEM

A. Structural Steel for Soldier Piles: ASTM A690/A690M H-piles or ASTM A36/A36M wide-flange I-beams or H-beams as applicable.

B. Cement Grout: Two sacks of ASTM C150, Type I, Type II, or Type III cement per cubic yard of grout, combined with ASTM C33 fine aggregate, to provide a flowable filler mix.

C. Steel Casings: Provide temporary drill casings where required to prevent caving of unstable soils.

2.06 SOIL MIX WALL SYSTEM

A. Soldier Piles: As specified above in Article 2.05.A, as applicable.

B. Materials and Equipment: Provide all materials and special equipment as required to perform the augering, mixing, and grout injection and to complete the soil-mix wall system.

PART 3 – EXECUTION

3.01 DETECTION OF MOVEMENT

A. For each existing structure and track or facility within a zone of influence extending upward from the bottom of the excavation on a slope of 2 horizontal to 1 vertical, install settlement detection devices on each footing, foundation, wall, or other feature to be monitored. Settlement detection devices shall be capable of being read to an accuracy of 0.005 foot.

B. Take and record readings not less than once per week during performance of the work.

C. Stop work; notify the Engineer, and take immediate remedial action if movement of the existing structure occurs during performance of the work. All construction activities shall be immediately halted when the settlement of any structure or facility reaches 0.3 inch, and shall not be resumed until after implementation of approved remedial measures. Consult Engineer for track monitoring requirements.

D. Upon completion of the work, take weekly readings of the measurement points for a period of 4 weeks, or longer if movement persists, and report the results to the Engineer.

E. The detection of movement shall be performed by a qualified licensed and surveyor or civil engineer.

3.02 INSTALLATION REQUIREMENTS

A. Existing footings, foundations, pile caps, grade beams, retaining walls or pavement which may be affected by excavation operations shall be shored or underpinned adequately or otherwise protected against settlement and lateral movement without relying on any other existing structures for stability or support.

B. Construct support systems in accordance with approved Shop Drawings and in a manner that will ensure that supported faces will be stabilized. Provide for additional soil pressure caused by adjacent surcharge loads.

C. Welding and welder's qualifications shall conform with applicable requirements of Section 05 05 22, Metal Welding.

D. No part of the excavation support systems that will remain permanently in place shall be placed or allowed to deflect within the limits of permanent structures.

E. Piles and vertical members of excavation support systems shall be within 1.0 percent of plumb and within 2 inches of the plan location indicated on approved Shop Drawings.

F. Install lagging members as indicated and in a manner which will prevent loss of soil. Wedge lagging members against undisturbed earth or place compacted fill or slurry fill into voids behind lagging.

G. Do not use combustible waste or similar material for packing or soil retention in excavations.

3.03 INSTALLATION OF SOLDIER PILES AND LAGGING

A. Provide pre-bored holes for soldier piles adequate to accommodate pile sections indicated. Extend holes to depth below level of adjacent sub grade as necessary to provide firm bearing. Piles may be driven below the bottom of the invert of the completed structure if soil conditions are favorable for the intended purpose.

B. After a pile has been seated plumb in the pre-bored hole, encase it with lean concrete from the bearing tip to level of adjacent sub grade excavation.

C. Provide timber lagging or reinforced precast concrete members, secured in place to soldier piles, contained in the recesses between the H-flanges. Install lagging horizontally with no gaps between boards or precast members.

D. As installation progresses, backfill voids between excavation face and lagging with sand or soil rammed into place. Provide drainage matting or burlap where necessary to allow drainage of ground water without loss of soil or sand packing.

E. If unstable material is encountered during excavation, take suitable measures to contain such material in place and to prevent soil displacement.

3.04 INSTALLATION OF SHEET PILING

A. Drive sheet piles in plumb position, with each pile interlocked with adjoining pile for its entire length so as to form a continuous diaphragm throughout the length of each run of wall. Drive to depth indicated.

B. Provide driving method so that interlocking members can be extracted, if required, without injury to adjacent fills.

C. Do not drive piles within 100 feet of concrete less than seven days old.

D. Methods of driving, cutting, and splicing shall conform with approved Shop Drawings and procedures.

3.05 CONSTRUCTION OF SLURRY WALLS

A. Slurry Trench Equipment:

1. Employ equipment capable of removing foreign material from the trench, including boulders. Arrange equipment to permit free vertical passage of slurry within the trench, and to prevent development of suction or pressure.

2. Furnish trench inspection tools or devices adequate to assure that the trench has been excavated to dimensions indicated on approved Shop Drawings, and that settled cuttings and excavated material have been removed.

3. Employ slurry mixing equipment capable of producing, with mechanical agitation, a stable suspension of bentonite and water. Transport bentonite slurry to trench panels by temporary pipelines or by other suitable methods.

4. Furnish equipment to provide circulation and agitation of the slurry throughout the full depth of excavated panels. Do not agitate slurry pneumatically.

5. Employ slurry reclaiming equipment which will remove detrimental quantities of excavated material from the slurry to assure use of clean slurry in trenches. Recirculate reclaimed slurry to trenches in a continuous operation.

6. Monitor slurry and control its capability for retaining solid particles in suspension.

B. Construction:

1. Construct slurry trench walls by displacing bentonite slurry with tremie concrete.

2. Construct walls of reinforced concrete or plain concrete with embedded structural steel, or unreinforced plain concrete as indicated on approved Shop Drawings. Where soldier piles are used in construction of walls, such piles may be considered as reinforcement.

3. Provide sufficient embedment of walls below subgrade of adjacent excavation to prevent heave, loss of ground due to piping under the wall, or lateral movement of the wall.

4. Perform preparatory work to discover, protect, maintain, relocate, and restore utility facilities and structures near the slurry walls.

5. Employ construction methods that assure that slurry materials provided during trench excavation and placing of tremie concrete are contained and controlled to prevent leakage and spillage of slurry and excavated materials into basements, vaults, utilities, and other facilities.

6. Excavate slurry wall trenches in panels of widths and depths indicated on approved Shop Drawings, with a maximum panel length of 18 feet. Reduce panel length when excavating adjacent to facilities sensitive to settlement.

7. Maintain wall panels full of slurry to within the limits indicated on approved Shop Drawings during excavating operations and until tremie concrete placement is completed. Continue construction with two panel spaces between two slurry panels under active excavation.

8. Keep slurry circulated or agitated during drilling and excavating, and immediately before concrete placement. Maintain slurry requirements at all times, including non-working periods and stoppages. Provide continuous circulation or agitation, if necessary, to meet these requirements.

9. Place concrete by tremie pipe, either by gravity flow or by pumping. Equip tremie pipe with a bottom valve to prevent mixing of slurry with the concrete inside of tremie pipe.

10. Start placement of tremie concrete in excavated panels within 12 hours of completion of excavating the panels, and proceed continuously until completion of concrete placement.

11. Construct tight joints between adjacent concrete placements by properly excavating the trench and cleaning abutting face of hardened concrete, or surfaces of structural members if used.

12. Seal leaks encountered in walls as the excavation progresses, if such leaks permit penetration of fines and loss of soil.

13. Dispose of unsuitable excavated material and debris in accordance with the requirements of Section 31 11 00, Clearing and Grubbing.

14. Dispose of slurry waste offsite in accordance with applicable regulations of governing authorities.

3.06 SUPPORT SYSTEMS WITH BRACING AND TIEBACKS

A. Requirements: Provide walers, struts, rakers, shores, and tie-backs as necessary to support excavation faces retained by posts, soldier piles, or concrete slurry walls.

B. Internal Bracing:

1. Provide walers where required, at each level of bracing. As excavation proceeds, place walers on open face of support system wall. Wedge, drypack, and otherwise provide tight bearing between walers and support system wall, with ample bearing areas to provide uniform transfer of loads.

2. Provide struts with intermediate bracing as needed to enable struts to carry the design load without distortion or buckling.

3. Provide diagonal bracing as needed for stability of the system.

4. Include web stiffeners, plates, angles, or bracing as needed to prevent rotation, crippling, or buckling of connections and points of bearing between structural members. Allow for eccentricities caused by field fabrication and assembly.

5. Install and maintain internal bracing support members in tight contact with each other and with the surface being supported.

6. Design internal bracing support members for maximum loads which may occur during excavation and removal stages.

C. Tie-Backs:

1. Provide tie-back anchorage system as necessary to support structures and excavations. Install tie-back system in accordance with approved Shop Drawings.

2. Tie-backs shall not extend beyond the BART right-of-way and easement properties, except as specified in Article 1.07.D.3. herein.

3. Install manufactured tie-back or anchorage systems in accordance with the manufacturer's instructions.

4. Stress installed tie-backs to proof loads indicated on approved Shop Drawings. Tie-backs which lose more than five percent of applied proof loads or deflect more than 6 inches shall be reinforced and strengthened to withstand applied proof loads.

5. Apply proof loads as herein specified, and provide means to measure each load application within an accuracy of plus or minus five percent.

6. After load-test approval, reduce tie-back proof load to the design load, and encase tie-back anchorage and bars or rods in grout, lean concrete, or compacted backfill, as indicated, maintaining the design load until tie-backs are fixed in place. Provide a method of fixation that will limit the load loss to not more than five percent of the design load in the transfer of loads from the jacks to the support system.

D. Proof Loading:

1. Perform proof loading of internal bracing members and tie-backs, including struts, shores, and similar members. Employ procedures that will produce uniform loading on bracing members and tie-backs without inducing eccentricities or overstressing and distortion.

2. Perform and accomplish proof loading by approved load testing or jacking procedures. Submit detailed Shop Drawings of proposed load testing and jacking procedures.

3. Apply proof loads as soon as possible after bracing and tie-backs are installed in accordance with methods, procedures, and sequences as indicated on approved Shop Drawings.

4. Coordinate excavation work with installation of bracing and tie-backs and with the application of proof loading. Provide steel shims and wedges, welded or bolted in place, to help maintain the proof-loading force on the bracing and tie-backs after release of load-testing pressures.

E. Creep Tests on Tie-Backs:

1. Load test tie-backs for creep at each level of support in the excavation, at the first installation on each side of the excavation, at horizontal intervals not exceeding 500 feet, and wherever a significant change occurs in the soil in which the tie-backs are anchored.

2. Perform a 24-hour load test on one out of each 100 tie-back anchors. Perform tests by applying the proof load and maintaining it constant for 24 hours.

3. Keep records of axial movement with incremental applications of the load, and the amount and time of load fall-off with no pumping of the jack or axial movement during the 24-hour period that the proof load on the anchor is maintained.

4. Redesign the tie-back system to attain specified limits if, during the 24-hour period, the axial deformation of the tie-back system exceeds 0.20 inch, or the decrease in jack pressure without pumping is more than five percent after correcting for temperature changes.

3.07 SOIL ANCHORS

A. Install soil anchors where necessary to support structures to be underpinned and those that will be affected by underpinning and restoration work. Other existing structures shall not be used to add stability or support to the temporary supports.

B. Installation and Testing Standards: Soil anchors shall be installed and tested in accordance with applicable requirements of PTI Post-Tensioning Manual, Chapter 4, Article 4.5, Soil Anchors.

C. Installation:

1. Angle tolerances shall be within one degree of those indicated on approved Shop Drawings.

2. Deviation from planned orientation shall be no more than 2 inches in 10 feet.

3. Drilling of anchor holes shall be by a proven system that utilizes a hollow stem auger or other approved method as appropriate for the soil conditions.

4. Clean or redrill any hole that caves, sloughs, or otherwise does not provide suitable anchorage.

5. Use spacers or sheathing to ensure that anchor tendons do not contact wall of drill hole. Maintain at least 2 inches of grout space around each tendon.

6. Do not extend adjustment screws on cross braces or centerhole jacks used for loading soil anchors beyond manufacturer's recommendations or two-thirds of threaded length, whichever is more restrictive.

7. Each jack used to stress tendons shall be equipped with a pressure gage for determining the jacking load applied to the tendon. Pressure gages shall have an accurate reading dial at least 4 inches in diameter or a clearly readable digital display.

8. The tensioning process shall be conducted so that the tension being applied and the elongation of the pre-stressing steel may be measured at all times. A record shall be kept of gage pressures, elongations, and anchorage seating values and shall be submitted for record as specified in Section 01 78 39, Project Record Documents.

9. Grout shall be injected at the lowest part of the anchor. Grout may be placed through the stem of the auger, through grout hoses, tubes, or pipes. Non-rigid hoses shall be attached to the lower end of the anchor with a break-away attachment that permits the hose to be removed as grout is placed. Pump pressure shall be maintained as grout hose or tube is removed.

10. Locate soil anchors so as not to damage or destroy active utility facilities. Any deviation shall obligate the Contractor to repair, replace, or otherwise restore such damage to the satisfaction of the utility owner.

D. Tests: Test each soil anchor after being grouted for its entire bond length and after grout has attained a minimum compressive strength of 3000 psi. One anchor or one percent of anchors in any wall section, whichever is greater, shall be designated as a performance test anchor. Performance test anchors shall be installed and tested prior to placement of production anchors. All production anchors shall be proof tested.

3.08 SOIL NAILING

A. Installation of Nails:

1. Soil nails shall be installed at locations and to the depths indicated on approved Shop Drawings, employing a drilling and grouting method appropriate for the soil in which they are to be installed.

2. Dewatering, as specified in Section 31 23 19, Dewatering, shall be performed in advance of soil nailing work to facilitate soil nailing in dry soil conditions.

3. Provide nail length and nail diameter necessary to develop the load capacity and to satisfy testing acceptance criteria for the required design load, but not less than the lengths and diameters indicated on approved Shop Drawings.

4. An initial cut in the soil shall be made to a depth governed by the ability of the soil to stand unsupported, but not greater than the required vertical spacing of the soil nails.

5. Drill holes for soil nails at locations indicated on approved Shop Drawings, with the actual location within 6 inches of the indicated location. The nail angle shall be located within plus or minus 3 degrees of that indicated on approved Shop Drawings. Adjust dimensions to suit field conditions.

6. Core drilling, rotary drilling, percussion drilling, auger drilling, or driven casing may be employed for soil nailing. Choose drilling methods that will maintain open drill holes and which do not promote mining and loosening of the soil at the perimeter of the drill hole. Where groundwater or local seepage causes holes to cave in, revise the drilling procedure to provide continuous support of the hole.

B. Grouting:

1. Provide grouting equipment capable of continuous mixing, producing a grout of proper consistency free of lumps. Nails shall be placed in each drilled hole within 15 minutes of the grout injection.

2. Place centralizers at 10-feet intervals in the total length with the last centralizer 1 foot from the end of each nail, and ensure that not less than 1-1/2 inches of grout cover is achieved around and along the nail. Centralizers may be omitted when pressure-grouting through hollow stem augers with a stiff grout mixture of 8 inches or less slump.

3. Inject or pump grout at the lowest point of the drill hole. Pump grout through grout tubes, casing, hollow-stem augers, or drill rods, such that the hole is filled free of air voids, with the grout filling the hole progressively from bottom to top. Inject or pump grout until the hole is completely filled and clean grout is seen to be running from the top of the hole.

4. Subsequent excavation shall not proceed until the grout has attained a minimum compressive strength of 1,000 psi.

C. Shotcreting:

1. As soon as practicable after soil nails are installed, cover the excavated wall face with a layer of reinforced shotcrete.

2. Shotcrete shall conform to the requirements of Section 03 37 13, Shotcrete. Provide straight, plane surface with cutting screed.

3. Just before shotcreting, provide drainage matting over the wall face to relieve hydrostatic pressure conditions. Drainage shall be collected at the wall base and properly directed to drainage outlets.

4. Also, just before shotcreting, tighten each nail nut one-half turn past snug tight. Pre-stressing is not required.

5. Wet set or provide other suitable method, such as dry pack, to provide even bearing against the shotcrete face, between the plate and the shotcrete.

D. Tests:

1. Provide a complete proof loading program. At least one nail per 100 linear feet of wall at each excavation level shall be tested. In addition, designated performance or sacrificial nails shall be tested to failure.

2. Soil nails shall not be tested until the anchorage grout has attained a minimum compressive strength of 3,000 psi.

3. Apply an alignment load (plus or minus 10 percent of the design load) and record the nail position.

4. Apply and increase the soil nail load in progressive steps of 25, 50, and 75 percent of the test load, and record the nail movement at each step. Maintain each incremental load for a minimum of one minute.

5. Bring the soil nail load up to 100 percent (test load) and, after movement has stopped, maintain the load for five minutes. The time period may need to be adjusted, based on the soil nail performance.

6. The following are acceptable nail movements:

   a. Total nail deformation shall be limited to 1 inch.

b. Nail movement during the five-minute 100 percent test load shall be limited to one-tenth of an inch.

7. Reduce soil nail load to zero and tighten nut.

8. Based on these test results, adjust soil nail hole diameter, nail lengths, and spacings as required.

3.09 SECANT WALLS

A. Design and construct secant walls as indicated or required. Drill beam holes and intersecting pier holes in sequence selected. Provide arched configuration of piers between beams. Provide temporary casings if necessary to prevent cave-ins of unstable soils. Set and align H-beams where they occur. Place toe concrete in beam holes to within 6 inches of the design sub grade. Fill balance of beam holes and intersecting pier holes with a cement grout filter mix. Concrete and cement grout may be end-dumped, provided drill holes remain stable during placement.

3.10 SOIL MIX WALLS

A. Design and construct soil-mix walls as indicated or required. Construct walls in the ground without excavating and replacing the existing soils. Existing soils shall be mixed in place with cement grout, produced by multiple-shaft augering equipment, forming a row of overlapped soil-cement columns or piers that make the wall. Install regularly spaced H-piles for wall reinforcement as indicated on approved Shop Drawings. Carry toe of wall and H-piles at least 3 feet below design sub grade.

3.11 REMOVAL OF EXCAVATION SUPPORT SYSTEMS

A. Excavation support systems shall be removed wholly, unless otherwise approved by the Engineer or stated in this specification section. Perform such removal in a manner that will not disturb or damage adjacent buildings, structures, construction, or utilities. Fill voids immediately with lean concrete or with approved backfill compacted to the relative compaction for the location as specified in Section 31 00 00, Earthwork.

B. Excavation support systems shall be left in place until the concrete walls and structures to receive the transferred loading from the removed support system have reached 100 percent of the specified compressive strength at 28 days. Demonstrate with strength test results that the concrete has reached the specified strength before load transfer from the support system to the concrete structure may be performed.

C. Secant walls and soil-mix walls shall be left in place.

D. Remove from the site all elements of excavation support systems to 6 feet minimum depth below the level of surfaces to be constructed or restored.

E. Repair damage to properties resulting from removal work.

3.12 RESTORATION

A. Restore existing structures to conditions equivalent to those existing prior to the start of work, including repair of settlement-related damage.

END OF SECTION 31 50 00

SECTION 31 62 00

DRIVEN PILES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Pile Types

B. Determination of Length

C. Indicator Piles and Test Piles

D. Axial Compression and Tension Load Tests

E. Lateral Load Tests

F. Dynamic Pile Testing

G. Installation of Piles

1.02 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for driven piles will be either by the lump-sum method or by the unit-price method as determined by the listing of the bid item for driven piles indicated in the Bid Schedule of the Bid Form.

B. Lump Sum: If the Bid Schedule indicates a lump sum for driven piles, the lump-sum method of measurement and payment will be in accordance with Section 01 20 00, Price and Payment Procedures, Article 1.03.

C. Unit Price: If the Bid Schedule indicates a unit price for driven piles, the unit-price method of measurement and payment will be as follows:

1. Measurement:

   a. Furnishing of piles of designated lengths, including test piles/indicator piles, delivered to the site, will be measured for payment by the linear foot for the full length of the pile.

   b. Driving of piles, including designated test piles/indicator piles, will be measured for payment as individual units (each), per each pile driven and accepted, regardless of pile length driven, tip elevation, or penetration. Driving of piles will include cutoffs. Cutoffs shall become the property of the Contractor and shall be removed from the site.

   c. Load testing of test piles, axial compression and tension, lateral and dynamic tests will be measured for payment per each test performed.

d. Pile extensions will not be measured separately for payment, but will be included in the measurement of furnishing the pile. Splices will not be measured separately for payment.

e. Rejected piles will not be measured separately for payment. Extracted rejected piles shall become the property of the Contractor and shall be removed from the site.

f. Pre-drilling will not be measured separately for payment, but will be included in the measurement of driving the pile.

2. Payment: Driven piles will be paid for at the indicated Contract unit prices for the computed quantities as determined by the measurement method specified in Article 1.02.C.1.

1.03 DEFINITIONS

A. Indicator Pile: An individual pile that is tested and observed to determine its behavior during or after initial driving.

B. Test Pile: An individual pile which is tested and observed under static axial compression or tension load, under lateral load, and under dynamic load tests.

C. Reaction Pile: An individual pile that provides the reaction load required to perform the load test on a test pile. During this process the reaction pile can be subjected to either an axial compression load or an axial tension load, or lateral load.

D. Dynamic Load Test Pile: An individual pile that is dynamically tested to estimate the vertical capacity using a Pile Driving Analyzer (PDA).

E. Production Piles: Piles that are purchased and delivered for incorporation in the permanent structure.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM A36/A36M — Standard Specification for Carbon Structural Steel
2. ASTM A252 — Standard Specification for Welded and Seamless Steel Pipe Piles
3. ASTM A690/A690M — Standard Specification for High-Strength Low-Alloy Nickel, Copper, Phosphorus Steel H-Piles and Sheet Piling with Atmospheric Corrosion Resistance for Use in Marine Environments
4. ASTM A760/A760M — Standard Specification for Corrugated Steel Pipe, Metallic-Coated for Sewers and Drains
5. ASTM A929/A929M — Standard Specification for Steel Sheet, Metallic Coated by the Hot-Dip Process for Corrugated Steel Pipe

6. ASTM D1143/D1143M Standard Test Methods for Deep Foundations Under Static Axial Compressive Load

7. ASTM D3689/D3689M Standard Test Methods for Deep Foundations Under Static Axial Tensile Load

8. ASTM D3966/D3966M Standard Test Methods for Deep Foundations Under Lateral Loads

9. ASTM D4945 Standard Test Method for High Strain Dynamic Testing of Deep Foundations.

B. American Welding Society (AWS):

1. AWS D1.1/D1.1M Structural Welding Code - Steel

1.05 REGULATORY REQUIREMENTS

A. Comply with applicable requirements of the California Code of Regulations, Title 24, Part 2, California Building Code, Chapters 18 and 18A, “Soils and Foundations.”

1.06 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit Shop Drawings of pile types as follows:

1. Type A: Show typical details of size, weight, splices, tip construction, and welding of splice connection.

2. Type B: Show typical details of sizes, configuration, tip construction, and welding of section connection, and class of concrete fill.

3. Types C and D: Show typical details of sizes, configurations, tip construction, and welding of section connections, and class of concrete fill.

4. Type E: Show typical details of sizes, configuration, pre-stressing steel, tendon arrangement, class of concrete, lifting devices, curing methods, and pre-stressing methods. Include engineering calculations of working stresses. If splicing is required, submit details.

5. Test Piles: Show tension steel reinforcement and connections for uplift loads.

C. Pile Driving Sequential Layout:

1. Submit layout drawings showing the proposed sequence of driving indicator, test and production piles.

2. On the sequential layout, show each pile by identification, its driving sequence number, type, size, load bearing capacity, and pile tip elevation as planned.

3. Submit a pile numbering plan that clearly identifies and numbers each pile for reference.

D. Pile Driving Record. Maintain a pile driving record during pile driving and submit it upon completion of each day's pile driving. On the record indicate, for each pile driven, the information specified in Article 1.06.C above, and the following: type and rating of driving equipment, dimensions of pile (size and length), overall blow count per foot and number of blows per inch penetration for the last 12 inches, final tip elevation at end of driving, and any unusual conditions encountered during driving. Also record start and end time of pile installation.

1. The Contractor shall submit a certified copy of the pile driving record to the Engineer for record purposes.

E. Equipment Review and Drawings:

1. Submit complete list of the equipment proposed for use, including a description of the characteristics of each piece of driving equipment.

   a. The Engineer will review the proposed driving equipment, accessories, and methods as a check of the adequacy of the equipment and methods for the conditions expected to be encountered.

   b. Should the equipment used by the Contractor prove to be inadequate to drive the scheduled types of piles at the locations indicated, or should the use of accessories show damage to the piles, or should it be found that the Progress Schedule cannot be maintained because of inadequate equipment or methods, the Contractor shall replace or use different types of equipment and accessories, or both, as appropriate for the conditions encountered.

2. Submit Shop Drawings of driving accessories showing compatibility with the size, configuration, handling, and driving requirements of each type of pile indicated.

3. Submit Shop Drawings showing the methods and equipment proposed for loading test piles.

1.07 QUALITY ASSURANCE

A. Pile Requirements: General and specific pile requirements shall comply with the California Building Code, Sections 1810, and 1810A, Deep Foundations, as applicable. However, where the Contract Drawings or Specifications indicate or specify materials and construction of a better quality, higher standard, or larger size than is required by said California Building Code, the provisions of the Contract Drawings and Specifications shall take precedence over the California Building Code.

B. Installation Tolerances:

1. Deviation from plumb and angle of batter: 1/4 inch per foot of pile length, but not more than 6 inches overall.

2. Deviation from location of pile top: 6 inches.

C. Piles delivered to the site that are cracked, bowed, chipped, under size, or that break under driving stresses shall be rejected. Remove such piles from the site and replace with sound piles. Piles broken under driving stresses may be cut off and left in place if approved by the Engineer for the location.

D. Welding and welders' qualifications shall conform to the applicable requirements of Section 05 05 22, Metal Welding.

PART 2 – PRODUCTS

2.01 PILES

A. Type A Piles: Steel H-piles conforming to ASTM A690/A690M, of size and type indicated. Steel plates and welding shall conform to applicable requirements of Section 05 12 00, Structural Steel Framing, and Section 05 05 22, Metal Welding.

B. Type B Piles:

1. Shell: Steel pipe conforming to ASTM A252, Grade 2, welded or seamless, of diameter and shell thickness indicated. Steel plates and welding shall conform to applicable requirements of Section 05 12 00, Structural Steel Framing, and Section 05 05 22, Metal Welding. For closed end pipe piles, end plates shall be structurally designed and adequately connected to the steel pipe to resist predicted driving stresses at the pile tip during installation.

2. Concrete Reinforcement: Conform to applicable requirements of Section 03 20 00, Concrete Reinforcing, of grades and sizes indicated.

3. Concrete: Conform to applicable requirements of Section 03 30 00, Cast-in-Place Concrete, and Section 03 05 15, Portland Cement Concrete. Provide minimum Class 3000-1-inch concrete unless otherwise indicated.

C. Types C and D Piles:

1. Shells:

a. Type C Piles: Corrugated cylindrical pipe conforming to ASTM A760/A760M, of diameter and sizes indicated.

b. Type D Piles: Tapered or step-tapered corrugated steel shell fabricated of corrugated sheet conforming to ASTM A929/A929M, or pipe sections conforming to ASTM A760/A760M of progressively larger or smaller sizes to meet indicated requirements.

c. Shell Thicknesses: Provide thickness or gage of metal and shell reinforcement of sufficient strength and rigidity to permit installation, and to prevent distortion caused by soil pressures after removal of the mandrel.

d. Tip: ASTM A36/A36M steel plate, of thickness as indicated, welded to shell.

2. Concrete Reinforcement: Conform to applicable requirements of Section 03 20 00, Concrete Reinforcing, of grades and sizes indicated.

3. Concrete: Conform to applicable requirements of Section 03 30 00, Cast-in-Place Concrete, and Section 03 05 15, Portland Cement Concrete. Provide minimum Class 4000-1-inch concrete unless otherwise indicated.

D. Type E Piles: Pre-cast, pre-stressed concrete piles, of sizes and requirements indicated, conforming to applicable requirements of Section 03 05 18, Pre-stressed Concrete. Provide minimum Class 6000-1-inch concrete unless otherwise indicated.

PART 3 – EXECUTION

3.01 PILE TYPES

A. Piles shall be friction piles or combined friction and end-bearing piles as indicated. Piles shall be driven to the required penetration, as indicated.

3.02 DETERMINATION OF LENGTH

A. Piles shall be of such lengths as required to develop the specified capacity, to obtain the specified penetration, and to extend into the pile cap or footing block as indicated.

B. The Contract Drawings indicate the required type of piling, the required compression and tension capacity, the minimum penetration, and the estimated pile tip elevation. Estimated tip elevations are approximate, based upon subsurface explorations, and are given only to indicate the required lengths of indicator piles and test piles.

C. Lengths of production piles will be determined by the Engineer from the data obtained during the driving of indicator piles and the load-testing of test piles.

D. The Engineer will furnish the Contractor with the production-piles' order list after completion of driving of indicator piles and load-testing of test piles.

3.03 INDICATOR PILES AND TEST PILES

A. Based upon available subsurface information and the geotechnical report, the Contractor shall order and drive the indicator piles and test piles. Compression and tension capacities of the test piles shall be determined by methods hereinafter specified. In general, the specified length of indicator piles and test piles will be greater than the estimated length of production piles in order to provide for variation on soil conditions.

B. Locations for the indicator piles and test piles shall be near existing subsurface exploration data (i.e. borings and/or CPTs) where the depth of exploration extends to at least the depth of the proposed tip elevation of the indicator or test pile.

C. Piles shall be driven with impact hammers unless otherwise indicated. Driving equipment used for driving indicator and test piles shall be identical to that what the Contractor proposes to use for the driving of production piles.

D. The Contractor shall excavate the ground at each indicator and test pile to the elevation of the bottom of the pile-cap footing before the pile is driven, or the Contractor may employ “followers” to compensate for the extra depth.

E. Indicator piles and test piles shall be driven to a hammer blow count established by the Engineer at the estimated tip elevation. Test piles that do not attain the hammer blow count specified above at a depth of 1 foot above the estimated tip elevation indicated shall be allowed to “set up” for a minimum of 24 hours before being re-driven. In areas where indicator piles are predominately supported in clay or silt, al longer “set up” time of 48 hours or more will be required. A cold hammer shall not be used for re-drive. The hammer shall be warmed up before driving begins by applying at least 20 blows to another pile.

F. If the specified hammer blow count is not attained on re-driving, the Engineer may direct the Contractor to drive a portion or all of the remaining pile length and repeat the “set up” – re-drive procedure. Piles shall be driven to the planned grade and, when not having the hammer blow count required, shall be spliced and driven until the required bearing is obtained or a new indicator pile shall be driven and allowed to “set up” for a longer time being re-driven.

G. A record of driving of indicator and test piles will be prepared by the Engineer that will include the number of hammer blows per foot for the entire driven length, the as-driven length of the test pile, cutoff elevation, penetration in ground, and any other pertinent information. If re-drive is necessary, the Engineer will record the number of hammer blows per inch of pile movement for the first foot of re-drive. The Contractor shall not order production piles until indicator and test pile data has been reviewed and pile order lengths are authorized by the Engineer in writing.

H. The Engineer may require the Contractor to install additional indicator piles that are not indicated, in the event that the behavior of the indicator pile or any other pile shows any peculiarity, erratic action, or otherwise causes suspicion as to the reliability of the pile capacity.

3.04 AXIAL COMPRESSION AND TENSION LOAD TESTS

A. Install test piles and reaction piles, of the same type and kind as permanent piles, in the locations indicated or at other locations as required by the Engineer.

1. Reinforce test and reaction piles for the full length to resist uplift loads.

2. Install test piles vertically.

B. Load test requirements including design loads shall be as indicated in the Contract Specifications or Contract Drawings.

C. Test piles that pass the load test in an undamaged condition may be utilized as permanent piles in the work. Reaction piles that were used to perform the pile load test may be utilized as permanent piles in the work, provided they are not damaged and that they have not moved upward more than 1/8 inch. If upward movement has occurred, piles shall be re-driven to the previous elevation.

D. Either extract damaged test piles and reaction piles and remove from the site, or cut them off 3 feet below any structure to be installed above. Holes shall be backfilled with concrete or grout.

E. Compression Load Tests: Tests shall be performed in accordance with ASTM D1143/D1143M. Method of load test shall follow Procedure A: "Quick Test" as specified in ASTM D1143/D1143M, Section 8.1.2.

1. Commence loading of test piles not sooner than 72 hours after placement of concrete or 72 hours after installation of Type E piles. Type III cement may be used in test piles to accelerate achieving necessary minimum strengths.

2. The maximum test load shall be at least 2.5 times the design load as prescribed by the Engineer. Apply the load in increments equal to 10 percent of the maximum test load, with a constant time interval between increments of 5 minutes. Maintain the maximum test load for not less than 15 minutes, unless the shaft has failed as determined by the Engineer.

3. Remove the test load in increments equal to 25 percent of the maximum test load, with a constant time interval between increments of 5 minutes.

4. Measure the settlement and rebound of the test pile to the nearest 0.01 inch.

F. Tension Load Tests: Tests shall be performed in accordance with ASTM D3689/D3689M. Method of load test shall follow Procedure A: "Quick Test" as specified in ASTM D3689/D3689M, Section 8.1.2. The maximum test load shall be at least twice the design load as prescribed by the Engineer. Apply the load in increments equal to 10 percent of the maximum test load, with a constant time interval between increments of 5 minutes. Maintain the maximum test load for not less than 15 minutes, unless the pile has failed as determined by the Engineer. Remove the test load in increments equal to 25 percent of the maximum test load, with a constant time interval between increments of 5 minutes.

G. Allowable bearing capacity of the test pile shall be defined as 40 percent of the failure load. For piles 24 inches or less in diameter or width, the failure load of a pile tested under axial compressive load is that load that produces a settlement at failure of the pile head equal to:

$$S_f = S + (0.15 + 0.008D)$$

Where:

S_f = Settlement at failure in inches

D = Pile diameter or width in inches

S = Elastic deformation of total unsupported pile length in inches

A. The Engineer may require the Contractor to make additional load tests that are not indicated, in the event that the behavior of the test pile or any other pile shows any peculiarity, erratic action, or otherwise causes suspicion as to the reliability of the pile capacity.

B. Immediately following completion of load testing, submit two copies of the test report for each test pile to the Engineer for record purposes. Include in the test report the data required by ASTM D1143/D1143M and ASTM D3689/D3689M, as applicable.

C. Following the completion of load tests, the Engineer will make a determination of the required penetration.

3.06 LATERAL LOAD TESTS

A. Tests shall be performed in accordance with ASTM D3966/D3966M. Method of load test shall follow Procedure A: “Standard Loading” as specified in ASTM D3966/D3966M, Section 8.1.2.

B. Load test requirements shall be as indicated in the Contract Specifications or Contract Drawings.

1. Piles capacity to resist wind loading. Applies the lateral load until the test pile displaces 0.25 inches horizontally.

2. Pile capacity to resist Design Basis Earthquake (DBE). Applies the lateral load until the load-displacement curve first exhibits non-linear (change of slope) displacements from the lateral load testing.

3. The pile capacity to resist DBE shall be determined by the structural engineer responsible for the design of the structures in accordance with BART Standards Specifications, Facilities Design, Structural, Foundations.

4. Pile capacity to resist Maximum Considered Earthquake (MCE) or other Extreme Limit States. Applies the lateral load until load-displacement curve first exhibits zero slope displacements (plateau) from the load testing.

5. The pile capacity to resist MCE shall be determined by the structural engineer responsible for the design of the structure in accordance with BART Standard Specifications, Facilities Design, Structural, Foundations.

6. For piles supporting building structures, the lateral pile load capacity shall be determined and verified with the lateral load testing specified in Chapter 18 of CBC, Section 1810, Deep Foundations.

3.07 DYNAMIC PILE TESTING

A. Dynamic pile testing shall be performed in accordance with ASTM D4945.

B. Dynamic measurements shall be taken by the Contractor during the driving of test piles designated as dynamic load test piles.

C. Prior to placement in the leads, the Contractor shall make each designated concrete pile available for taking wave speed measurements and for pre-drilling the required instrument attachment holes. Pre-driving wave speed measurements will not be required for steel piles. When wave speed measurements are made, the piling shall be in a horizontal position and not in contact with other piling.

D. The Contractor shall furnish the equipment, materials, and labor necessary for drilling holes in the piles for mounting the instruments. Instruments will be attached near the head of the pile with expansion-type bolts for concrete piles or through drilled holes on steel piles.

E. The Contractor shall provide safe access to the pile for personnel to attach instruments after the pile is placed in the leads.

F. The Contractor shall furnish electric power that is compatible for the dynamic test equipment. Field generators used as the power source shall be equipped with meters for monitoring voltage and frequency levels.

G. The Contractor shall drive the pile to the design tip elevation or other depth specified by the Engineer. The stresses in the piles will be monitored during driving with the dynamic test equipment to ensure that the values determined do not exceed the allowable values. If necessary, the Contractor shall reduce the driving energy transmitted to the pile by using additional cushions or reducing the energy output of the hammer in order to maintain stresses below the allowable values. If non-axial driving is indicated by the dynamic test equipment measurements, the Contractor shall immediately realign the driving system.

H. The Contractor shall wait up to a minimum of 24 hours and, after the instruments are re-attached, re-tap the dynamic load test pile. A cold hammer shall not be used for the re-drive. The hammer shall be warmed up before re-drive begins by applying at lead 20 blows to another pile. The minimum amount of penetration required during re-drive shall be 6 inches, or the maximum total number of hammer blows required will be 50, whichever occurs first. After re-tapping, the Engineer will either provide the cut-off elevation or specify additional pile penetration and testing for that dynamic load test pile. CAPWAP analyses of dynamic pile testing data shall be performed on data obtained for the beginning of re-drive of the driven piles.

3.08 INSTALLATION OF PILES

A. Pile Types: Provide piles of the type indicated and of the length and configuration as determined by the Engineer in accordance with the following:

1. The Final Geotechnical Engineering Report, data from the tested piles and the indicator piles.

2. Extend into the pile cap or structure footing to the location indicated; and

3. Attain indicated capacity.

B. Penetration and Bearing: Install piles to the required penetration, or to the required bearing, as determined by the various load tests performed for the purpose. Jetting will not be permitted unless specifically approved in writing by the Engineer for the location.

C. Predrilled Holes:

1. Where piles are to be driven through new embankment and the depth of the embankment is greater than 5 feet at the pile location, drive the pile in a hole, drilled through the embankment, of diameter not less than the greatest cross-section dimension of the pile. After driving the pile, fill any annular space around the pile with dry sand or pea gravel.

2. When necessary to achieve the required penetration, drill holes of diameter not greater than 90 percent of the least cross-sectional dimension of the pile at the depth being drilled, and drive the pile therein to the required penetration. Locations and types of pre-drilling shall be approved by the Engineer in writing.

3. When, in the Contractor's opinion, a larger hole is needed to prevent damage to piles, submit substantiating data and obtain the Engineer's written approval before drilling holes of larger cross-section. Holes greater than 100 percent of the cross-sectional dimension of the pile will not be permitted.

D. Pile Driving:

1. Complete embankment construction, filling, and backfilling to the required elevations before starting of pile-driving operations. Unless otherwise specified, an embankment settlement period of at least six months will be required before installation of piles.

2. Do not drive piles within 20 feet of concrete less than seven days old.

3. Drive interior footing piles before driving perimeter piles.

4. If necessary, provide adequate lateral support for installed individual piles to prevent excessive temporary flexural stresses or movement of the pile top out of tolerance.

5. Maintain the hammer coaxial with the pile during the driving operation by using a combination of driving cap and leads.

6. Investigate any sudden decrease in driving resistance for possible breakage of the pile. If a sudden decrease in driving resistance cannot be correlated to boring data or some incident in the driving, and if the pile cannot be inspected, such decrease in driving resistance will be cause for rejection of the pile.

7. Re-drive any pile that is raised during driving of adjacent piles, to the original tip elevation.

8. Splice piles only by methods and at places approved by the Engineer in writing.

9. Cut off piles at top elevation indicated. Repair piles that are damaged when cut off requires written approval of the Engineer.

E. Type A Piles:

1. Design the driving cap with grooves in the base to conform loosely to the “H” configuration of the pile. The bearing surface of the grooves shall be true, without roughness. The driving cap shall extend down the side of the pile at least four inches and shall be loosely attached to the hammer so that it will at all-times rest squarely over the entire surface of the pile.

2. Make splices as indicated by electric-arc field welding in accordance with AWS D1.1/D1.1M. Cut-off damaged portion of pile top before splicing. Take care to align the sections connected so that the axis of the pile will be straight. Refer to Section 05 05 22, Metal Welding, for welding requirements.

F. Type B Piles:

1. Protect the heads of piles from direct impact of the hammer by using an approved head block or shoe.

2. Make splices as indicated by electric-arc field welding in accordance with AWS D1.1/D1.1M. Cut-off damaged portion of pile top before splicing. Take care to align the sections connected so that the axis of the pile will be straight. Refer to Section 05 05 22, Metal Welding, for welding requirements.

3. Remove rejected pipe pile and replace with new pipe. When rejected pipe pile cannot be removed, furnish and install replacements. Cut off abandoned pipe 3 feet below the structure, and fill the abandoned pipe with Class 3000 concrete. Backfill and compact holes.

4. Concrete to be placed using tremie pipe that can extend to the bottom of the pipe. Concrete will not be allowed to free fall during placement. Vibration of the concrete will not be required except in the top 15 feet of the pipe. Discharge concrete into the hopper at a continuous and rapid rate. Any break in the placement of the concrete shall be the basis for rejection of the pile. The Contractor shall verify the integrity of the pile.

5. Pipe piles may be driven with open ends, and the soil, rock or deleterious material adequately removed with auger or by other approved method to width and depth indicated to allow concrete to bond to the inside of the pipe. Inspect driven pipe shell for internal damage and misalignment and for the presence of water, and correct damaged or defective conditions before placement of concrete. Piles partially filled with water shall be dewatered or concrete-filled using the tremie method.

G. Types C and D Piles:

1. Shells will be inspected for collapse, tears, splits, or reduced diameter throughout their length after shells have been driven and before reinforcing steel and concrete are placed therein.

2. Provide adequate inspection equipment, such as lights and CCTV/video tape equipment as required.

3. For acceptance, the pile shell shall be:

   a. Free of collapsed sections and tears;

   b. Free of water, except that a minor amount of water may be permitted if it can be absorbed by placing a suitable amount of dry sand-cement mixture in the tip of the pile, if this condition cannot be corrected in this manner then use method specified in Article 3.07 F.5. herein; and

   c. Visible to the bottom of the casing.

4. Remove rejected pile shells and replace with new shells. When rejected shells cannot be removed, furnish and install replacements. Cut off abandoned shells three feet below the structure and fill the abandoned shells with Class 4000 concrete. Backfill and compact holes.

5. Immediately prior to installing the reinforcing steel assembly, place a 1:2 sand-cement grout in bottom of pile shell to a minimum depth of 12 inches.

6. Assemble reinforcing steel as a complete unit and install in pile before starting to place concrete.

7. Concrete to be placed using tremie pipe that can extend to the bottom of the pipe. Concrete will not be allowed to free-fall during placement. Vibration of the concrete will not be required except in the top 15 feet of the shell. Discharge concrete into the hopper at a continuous and rapid rate. Any break in the placement of the concrete shall be the basis for rejection of the pile. The Contractor shall verify the integrity of the pile.

H. Type E Piles:

1. Protect the heads of piles from direct impact of the hammer by acceptable cushion head block, so that no cracking, spalling, or chipping occurs.

2. If piles have extended reinforcing steel and protective concrete for driving, remove such protective concrete to expose the reinforcing steel upon completion of driving.

3. When piles are driven or cut off below the elevation of the bottom of the cap, extend the pile to the elevation of the bottom of the cap by means of a reinforced concrete extension. Submit details for approval prior to fabrication.

END OF SECTION 31 62 00

SECTION 31 63 29

DRILLED CONCRETE PIERS AND SHAFTS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Method Test Shaft

B. Load Test

C. Excavation

D. Installation of Concrete Reinforcement

E. Concrete Placement

F. Withdrawal of Temporary Steel Casing

G. Field Quality Control

1.02 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for drilled shaft foundations will be either by the lump-sum method or by the unit-price method as determined by the listing of the bid item for drilled shaft foundations indicated in the Bid Schedule of the Bid Form.

B. Lump Sum: If the Bid Schedule indicates a lump sum for drilled shaft foundations, the lump-sum method of measurement and payment will be in accordance with Section 01 20 00, Price and Payment Procedures, Article 1.03, and will include reinforcing steel.

C. Unit Price: If the Bid Schedule indicates a unit price for drilled shaft foundations, the unit-price method of measurement and payment will be as follows:

1. Measurement:

   a. Concrete for drilled shaft foundations, of each diameter, including test shaft foundations, will be measured for payment by the linear foot of shaft depth, measured from the cut-off line to the bottom of the shaft.

   b. Reinforcing steel will be measured separately for payment as specified in Section 03 20 00, Concrete Reinforcing.

   c. Drilling of shafts (excavation), including drilling of method test shafts, will be measured for payment as individual units (each), per each shaft drilled and accepted.

   d. Load testing of drilled shaft foundations, both compressive and tension load tests, lateral load tests and ultrasonic crosshole testing, will be measured for payment per each load test performed.

e. Groundwater control, exploratory drilling, support of excavation for shaft foundations, and steel casing, whether withdrawn or left in place, will not be measured separately for payment; and all costs in connection therewith will be considered incidental to and included with the construction of drilled shaft foundations.

2. Payment: Drilled shaft foundations will be paid for at the indicated Contract unit prices for the computed quantities as determined by the measurement method specified in Article 1.02.C.1.

1.03 DEFINITIONS

A. The words and terms used in these Specifications conform to the definitions given in ACI 336.1.

B. The terms “drilled shaft” and “cast in drilled hole (CIDH) piles” are used interchangeably.

1.04 REFERENCES

A. International Association of Foundation Drilling (formerly Association of Drilled Shaft Contractors) (ADSC):

1. ADSC — Standards and Specifications for the Foundation Drilling Industry

B. American Concrete Institute (ACI):

1. ACI 336.1 — Specification for the Construction of Drilled Piers

C. American Society for Testing and Materials (ASTM):

1. ASTM D1143/D1143M — Standard Test Methods for Deep Foundations Under Static Axial Compressive Load
2. ASTM D3689/D3689M — Standard Test Methods for Deep Foundations Under Static Axial Tensile Load
3. ASTM D3966/D3966M — Standard Test Methods for Deep Foundations Under Lateral Loads
4. ASTM D6760 — Standard Test Method for Integrity Testing of Concrete Deep Foundations by Ultrasonic Crosshole Testing

D. California Code of Regulations:

1. Title 24, Part 2, California Building Code, Chapter 18, Soils and Foundations

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Concrete Reinforcement: Provide submittals in accordance with the requirements of Section 03 20 00, Concrete Reinforcing.

C. Qualifications of Welders and Welding Procedures: Provide submittals in accordance with requirements of Section 03 20 00, Concrete Reinforcing, for reinforcing steel, and with requirements of Section 05 05 22, Metal Welding, for casing steel.

D. Portland Cement Concrete: Provide submittals in accordance with the requirements of Section 03 05 15, Portland Cement Concrete. Include submittal for tremie concrete equipment and placement method.

E. Drilling Equipment: Submit description of equipment including but not limited to power rating, torque, downward thrust, and type and size of drilling tools to be used.

F. Records and Reports: Submit daily reports and shaft record reports or logs as required by ADSC's "Standards and Specifications for the Foundation Drilling Industry," using ADSC formats for forms.

1.06 QUALITY ASSURANCE

A. Construction Standards: Drilled shaft foundations shall be constructed in accordance with applicable requirements of ACI 336.1 and ADSC's "Standards and Specifications for the Foundation Drilling Industry."

B. Design Criteria:

1. Drilled shaft foundations shall consist of monolithically cast-in-place concrete piles of the sizes indicated.

2. Shaft foundations shall be straight cylindrical shaft type as indicated.

3. Shaft foundations shall extend from the indicated concrete cutoff elevation to the indicated tip elevation.

C. Tolerances:

1. Maximum variation of the center of any shaft foundation from the required location: 3 inches, measured at the ground surface.

2. Bottom Diameter: minus zero, plus 6 inches, measured in any direction.

3. Maximum variation from plumb: 1 (horizontal):40 (vertical).

4. Maximum bottom level tolerance: plus or minus 2 inches.

D. Inspection of Shaft Excavations:

1. The Contractor shall provide equipment for checking the dimensions and alignment of each shaft excavation. Dimensions and alignment shall be determined jointly by the Contractor and the Engineer. Final shaft depths shall be measured with an appropriate weighted tape measure or other approved method after final cleaning.

2. A minimum of 50 percent of the base of each shaft shall have less than 1/2 inch of sediment at the time of placement of concrete. Maximum depth of sediment or debris at any place on the base of the shaft shall not exceed 1-1/2 inches. Shaft cleanliness will be determined by the Engineer by visual inspection.

1.07 SEQUENCING AND SCHEDULING

A. Unless otherwise permitted by the Engineer, the Contractor shall schedule drilling or excavating, installation of reinforcing steel and concrete placement so that each excavated shaft is poured the same day that the drilling is performed.

B. Do not permit vibration or excessive wheel loads within the immediate vicinity of any shaft excavation until placement of concrete is complete. Maintain excavation stability at all times.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Concrete Reinforcement: Conform to applicable requirements of Section 03 20 00, Concrete Reinforcing, of grades and sizes indicated.

B. Concrete: Conform to applicable requirements of Section 03 30 00, Cast-in-Place Concrete, and Section 03 05 15, Portland Cement Concrete. Provide class of concrete indicated on the Contract Drawings. Where class of concrete is not indicated, provide Class 3000 concrete.

1. Prepare separate mix designs for each class of concrete.

2. Slump for concrete: Slump shall be 5 inches plus or minus 1 inch for dry shafts without temporary casing, and 7 inches plus or minus 1 inch for dry shafts with temporary casing.

C. Steel Casing:

1. Where earth wall of drilled shaft is unstable or has a tendency to slough, crumble, or fall away, provide temporary steel casing to stabilize the shaft wall.

2. Inside diameter of the casing shall be the full diameter of the drilled shaft foundation as indicated, plus or minus 1/2 inch.

3. Steel casing shall have adequate strength to withstand the pressure of concrete placement without distortion.

4. Inside surfaces of steel casing shall be smooth and coated to facilitate easy lifting and removal during placement of concrete.

2.02 EXCAVATING AND DRILLING EQUIPMENT

A. Excavating and drilling equipment shall have adequate capacity, including power, torque, and down thrust to excavate a hole of the maximum diameter and to a depth of 20 percent beyond the depth indicated. Excavation and overreaming tools shall be of adequate design, size, and strength to perform the work indicated.

B. When the material encountered cannot be drilled using conventional earth augers or overreaming tools, special drilling equipment shall be provided, including rock core barrels, rock tools, air tools, and other equipment as necessary to construct the shaft excavation to the size and depth indicated.

PART 3 – EXECUTION

3.01 METHOD TEST SHAFTS

A. The Contractor shall demonstrate the adequacy of the methods and equipment to be employed for excavating shafts by successfully constructing method test shafts. The number of test shafts shall be as indicated in the Contract Specifications or the Contract Drawings. The method test shafts shall include drilling, reinforcing steel, thread bars, and concrete placement.

B. Method test shafts shall be positioned away from the drilled shafts in the location indicated or where approved by the Engineer in writing. Method test shafts shall be drilled to the maximum depth of any drilled shaft indicated.

C. Method test shafts shall be located near existing subsurface exploration data (i.e. a boring or CPT) where the depth of exploration extends to at least to the proposed tip elevation.

D. Failure to demonstrate the adequacy of methods and equipment shall be sufficient reason for the Engineer to require alterations in equipment and methods by the Contractor to eliminate unsatisfactory results.

E. Once approval has been given to construct drilled shafts, no change will be permitted in the methods or equipment used to construct the satisfactory method test shaft without the written approval of the Engineer.

3.02 LOAD TESTS

A. Requirements:

1. The Contractor shall perform compression load tests, tension load tests, and lateral load tests as required to determine whether or not the shafts can carry and withstand the imposed loads. Tests shall be performed on the method test shafts. Except for shafts required for testing, additional shaft construction will not be permitted until the load tests are completed.

2. Load test requirements shall be as indicated in the Contract Specifications or Contract Drawings.

3. The Contractor shall provide all equipment and apparatus as required to conduct the tests.

4. The Contractor shall install, remove, relocate, and reinstall weights and components as necessary to perform and complete the tests.

5. Tests can be conducted as soon as practicable after the concrete in each drilled shaft has attained the specified 28-day compressive strength, but not until at least 10 days have elapsed after placing the concrete.

B. Compression Load Tests: Tests shall be performed in accordance with ASTM D1143/D1143M. Method of load test shall follow Procedure A: “Quick Test” as specified in ASTM D1143/D1134M, Section 8.1.2. The maximum test load shall be at least 2.5 times the design load as prescribed by the Engineer. Apply the load in increments equal to 10 percent of the maximum test load, with a constant time interval between increments of 5 minutes. Maintain the maximum test load for not less than 15 minutes, unless the shaft has failed as determined by the Engineer. Remove the test load in increments equal to 25 percent of the maximum test load, with a constant time interval between increments of 5 minutes.

C. Tension Load Tests: Tests shall be performed in accordance with ASTM D3689/D3689M. Method of load test shall follow Procedure A: “Quick Test” as specified in ASTM D3689/D3689M, Section 8.1.2. The maximum test load shall be at least twice the design load as prescribed by the Engineer. Apply the load in increments equal to 10 percent of the maximum test load, with a constant time interval between increments of 5 minutes. Maintain the maximum test load for not less than 15 minutes, unless the shaft has failed as determined by the Engineer. Remove the test load in increments equal to 25 percent of the maximum test load, with a constant time interval between increments of 5 minutes.

D. Lateral Load Tests: Tests shall be performed in accordance with ASTM D3966/D3966M. Method of load test shall follow Procedure A: “Standard Loading” as specified in ASTM D3966/D3966M, Section 8.1.2.

1. Drilled shafts and CIDH piers/piles capacity to resist wind loading. Applies the lateral load until the test shaft/pier/piles displaces 0.25 inches horizontally.

2. Drilled shafts and CIDH piers/piles capacity to resist Design Basis Earthquake (DBE). Applies the lateral load until the load-displacement curve first exhibits non-linear/bi-linear (change of slope) displacements from the latest load testing.

   The drilled shaft and CIDH pier/piles capacity to resist DBE shall be determined by the structural engineer responsible for the design of the structures in accordance with BART Standard Specifications, Facility Design, Structural, Foundations.

3. Drilled shafts and CIDH piers/piles capacity to resist Maximum Considered Earthquake (MCE) or other Extreme Limit States. Applies the lateral load until load-displacement curve first exhibits zero slope displacement (plateau) from the lateral load testing.

   The drilled shafts and CIDH piers/piles capacity to resist MCE shall be determined by the structural engineer responsible for design of the structures in accordance with BART Standard Specifications, Facility Design, Structural, Foundations.

4. For drilled shafts and CIDH piers/piles supporting building structures, the lateral pile load capacity shall be determined and verified with the lateral load testing specified in Chapter 18 of CBC, Section 1810, Deep Foundations.

3.03 EXCAVATION

A. General:

1. Excavate for shaft foundations by drilling or by other methods, as approved by method test shafts, to advance the excavation to the required bottom elevation as indicated on the Contract Drawings or as directed by the Engineer. Avoid over excavation. Excavation shall be performed through whatever materials are encountered to the dimensions, depths, and tolerances indicated. Bottoms of excavations shall be level and flat.

2. When required by the Engineer, drill and core an exploratory hole, approximately 3 to 4 inches in diameter, to a depth of 15 feet below the excavation invert and backfill with grout.

3. Protect excavated walls with temporary steel casing as necessary to prevent cave-ins, displacement of the surrounding earth, water incursion, injury to personnel, and damage from construction operations. Maintain indicated neat lines of excavation for cased areas.

4. Make bottom surfaces level within the tolerances specified herein. Remove loose material, debris, and muck with cleaning buckets.

B. Ground Water Control:

1. Notify the Engineer immediately when ground water is encountered.

2. Suitable steel casings shall be furnished and placed when necessary to control water. Drilling mud or chemical stabilizers shall not be used unless permitted by the Engineer.

C. Inspection: After completion of excavation and prior to placement of reinforcing steel, the condition of the excavation will be inspected by the Engineer. Use clean-out buckets or air-lifts to remove any slough or other loose material from the shaft prior to placing reinforcing steel and concrete. An accumulation of soil or rock in the bottom of the excavation will not be permitted.

3.04 INSTALLATION OF CONCRETE REINFORCEMENT

A. Where it is not practicable to deliver the cage assembly to the jobsite as a complete unit ready for installation, make the remaining connections or splices, as indicated on the approved Shop Drawings, at-grade prior to lowering the assembly into the hole.

B. Lower reinforcing steel into the hole in such a manner as to prevent damage to the walls and cause sloughing. Place and tie or clip symmetrically about the axis of the shaft. Use centering devices, securely attached to the cage, to clear the shaft walls and to maintain the cage in place throughout the concrete placement.

C. Set reinforcing steel at required location and elevation prior to concrete placement. Hold and support steel such that it does not move during concrete placement.

D. Check the elevation of top reinforcing steel before and after concrete placement. Make adjustments if steel cage position is not maintained.

E. Check depth of hole using a weighted tape before and after placement of the reinforcing steel. If more than 1 inch to the bottom of the hole is lost, remove cage and remove slough at bottom of hole.

3.05 CONCRETE PLACEMENT

A. Place concrete in dry excavations whenever practicable. Use all practicable means to obtain a dry excavation before and during concrete placement.

B. Concrete shall be placed as soon as possible after reinforcing steel installation. Concrete placement shall be continuous from the bottom to the top elevation of the shaft. Concrete placement shall continue until good quality is evident at the top of the shaft. Concrete shall be placed with a tremie pipe connected to a concrete boom truck.

C. Infiltration of groundwater at or near the bottom of the hole exceeding 1/4 inch rise per minute will be considered a wet placement.

D. Wet Concrete Placement

1. Fill hole with water or slurry to the natural water level to equalize the hydraulic head inside and outside the shaft excavation before starting concrete placement. Use only concrete mix designed for tremie placement.

2. Tremie shall be constructed such that it is watertight and will readily discharge concrete. The tremie shall be of sufficient length to permit the discharge end to be immersed in concrete at all times.

3. A plug or similar device shall be used to separate the concrete from the fluid in the hole until pumping begins. Once concrete placement begins, the tip of the tremie pipe shall be maintained to prevent reentry of the slurry into the pipe.

4. Flow of concrete shall be continuous and concrete in tremie shall have sufficient capacity to maintain a positive pressure differential at all times to prevent water or slurry intrusion into the shaft concrete.

3.06 WITHDRAWAL OF TEMPORARY STEEL CASING

A. Where temporary steel casings are used to support the excavation walls, withdraw the casing as the concrete is being placed, unless otherwise indicated or unless the Engineer requires that the casing be permanently grouted in place. Remove the steel casing in such a manner so that the lower edge of the steel liner will always remain a minimum of 5 feet below the surface of the concrete as placed to prevent water from entering the casing from the bottom. Vibrate concrete during withdrawal of the steel casing.

3.07 FIELD QUALITY CONTROL

A. Inspections and Tests: The Contractor shall perform inspections and tests of concrete as specified in Section 03 05 15, Portland Cement Concrete.

B. For large diameter drilled shafts (3 feet or larger in diameter) and for all drilled shafts or CIDH piles/piers encountering ground water, the Contractor is required to perform ASTM D6760, Ultrasonic Crosshole Testing to confirm the homogeneity and integrity of all of the drilled shafts and CIDH piers/piles. If any of the tested shaft or CIDH pile/pier fails to meet the testing requirements, the Contractor has to remedy the defects and to submit a plan to the Engineer for approval before proceeding, at no additional cost to BART.

C. Records and Reports: Keep a record, on an approved form, for each drilled shaft foundation installed. Record on the form the location, dimensions, elevations of top and bottom, depth of stratum penetration, condition of bottom of excavation, concrete placement data, a continuous record of actual concrete volume placed versus theoretical volume, and any other data called for on the approved report form or pertinent to the foundation.

END OF SECTION 31 63 29

SECTION 32 11 17

AGGREGATE SUBBASE COURSES

1.01 SECTION INCLUDES

A. Subbase materials.

B. Installation standards.

C. Spreading of material.

D. Compacting.

E. Field quality control.

1.02 RELATED SECTIONS

A. Aggregate base course for pavements is specified in Contract Specifications Section 32 11 23, Aggregate Base Courses.

B. Preparation of sub grade is specified in Contract Specifications Section 31 00 00, Earthwork.

1.03 CLASSIFICATION

A. Aggregate subbases are designated as Class 1, Class 2, or Class 3. The class of aggregate subbase shall be indicated.

1.04 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for aggregate subbase will be by the lump-sum method or by the unit price method as determined by the listing of the bid item for aggregate subbase indicated in the Bid Schedule of the Bid Form.

B. Lump Sum: If the Bid Schedule indicates a lump sum for aggregate subbase, the lump sum method of measurement and payment will be in accordance with the Lump-Sum Measurement in Contract Specifications Section 01 20 00, Price and Payment Procedures.

C. Unit Price:

1. If the Bid Schedule indicates a unit price for aggregate subbase, the unit price method of measurement and payment will be as follows:

    a. Measurement: Aggregate subbase will be measured for payment by the cubic yard for each class of aggregate placed in the Work. The quantity for payment will be based on the dimensions, neat lines or pay lines, and sections indicated on the Contract Drawings.

b. Payment: Aggregate subbase will be paid for at the indicated Contract unit prices for the computed quantities as determined by the measurement method specified in Article 1.04C herein.

1.05 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM C136/ C136M — Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
2. ASTM D1241 — Standard Specification for Materials for Soil-Aggregate Subbase, Base, and Surface Courses
3. ASTM D1557 — Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort
4. ASTM D2419 — Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate
5. ASTM D2844/ D2844M — Test Method for Resistance R-Value and Expansion Pressure of Compacted Soils
6. ASTM D6913/ D6913M — Standard Test Methods for Particle Size Distribution (Gradation of Soils Using Sieve Analysis)
7. ASTM D6938 — Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

B. State of California, Department of Transportation (Caltrans), Standard Specifications, latest edition:

1. Section 10-6 — Watering
2. Section 25 — Aggregate Subbases

1.06 SUBMITTALS

A. General: Refer to Contract Specifications Section 01 33 00, Submittal Procedures, for submittal requirements and procedures.

B. Product Data: Submit source, gradation, R-value, and sand equivalent for the proposed subbase material.

C. Test Reports: Submit plant and field test reports as specified in Articles 2.02 and 3.05 herein.

PART 2 – PRODUCTS

2.01 SUBBASE MATERIAL

A. Aggregates for the three classes of aggregate subbase shall conform to the requirements described in the materials section of Caltrans Standard Specifications Section 25.

2.02 SOURCE QUALITY CONTROL

A. The Contractor shall take, prepare, and perform sampling and tests of the aggregate subbase material as delivered to the site in accordance with the ASTM D6913/6913M Test Methods herein specified, to determine compliance with specified requirements.

B. Aggregate grading or sand equivalent test shall represent no more than 500 cubic yards of subbase material or one day's production, whichever is the lesser amount.

PART 3 – EXECUTION

3.01 EXAMINATION

A. The Contractor shall request an inspection by the Engineer and obtain acceptance of the prepared sub grade before proceeding with placement of the aggregate subbase.

B. Immediately prior to spreading, the sub grade to receive aggregate subbase, shall conform to the compaction and elevation tolerances indicated for the material involved and shall be free of standing water and loose or extraneous material.

3.02 INSTALLATION STANDARDS

A. Aggregate subbase shall be applied over the prepared sub grade and compacted in accordance with Section 25 of the Caltrans Standard Specifications.

B. Aggregate subbase shall be minimum uniform thickness after compaction of dimensions indicated. Where not indicated, compacted thickness shall be six inches.

C. Compaction expressed in percentage in this Section refers to the maximum dry density as determined by ASTM D1557.

3.03 SPREADING OF MATERIAL

A. Spreading of aggregate subbase material shall be by approved methods and conform to the requirements as described in Section 25 of the Caltrans Standard Specification.

3.04 COMPACTING

A. Compaction of aggregate subbase material shall be by approved methods and conform to the requirements as described in Section 25 of the Caltrans Standard Specification.

3.05 FIELD QUALITY CONTROL

A. The Contractor shall perform field tests in accordance with ASTM D6938 to determine compliance with specified requirements for density and compaction of subbase material, and with ASTM D6938 to determine moisture-content compliance of the installed subbase material.

B. Testing frequency shall be not less than one test for every 2,000 square feet of subbase material, per layer or lift.

END OF SECTION 32 11 17

SECTION 32 11 23

AGGREGATE BASE COURSES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Aggregate base material.

B. Installation standards.

C. Spreading of material.

D. Compacting.

E. Field quality control.

1.02 RELATED SECTIONS

A. Aggregate subbase for pavements and foundations is specified in Contract Specifications Section 32 11 17, Aggregate Subbase Courses.

B. Preparation of sub grade is specified in Contract Specifications Section 31 00 00, Earthwork.

1.03 CLASSIFICATION

A. Aggregate bases are designated as Class 2 or Class 3. The class of aggregate base shall be as indicated.

1.04 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for aggregate base course will be by the lump-sum method or by the unit-price method as determined by the listing of the bid item for aggregate base course indicated in the Bid Schedule of the Bid Form.

B. Lump Sum: If the Bid Schedule indicates a lump sum for aggregate base course, the Lump-sum method of measurement and payment will be in accordance with the Lump-Sum Measurement in Contract Specifications Section 01 20 00, Price and Payment Procedures.

C. Unit Price:

1. If the Bid Schedule indicates a unit price for aggregate base course, the unit price method of measurement and payment will be as follows:

a. Measurement: Aggregate base course will be measured for payment by the ton or cubic yard, as designated in the contract item, for each class of aggregate placed in the Work. If designated by cubic yard, the quantity for payment will be based on the dimensions, neat lines or pay lines, and sections indicated in the Contract Drawings.

b. Payment: Aggregate base course will be paid for at the indicated Contract unit prices for the computed quantities as determined by the measurement method specified in Article 1.04.C., herein.

1.05 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM C136/ C136M — Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
2. ASTM D1241 — Specification for Materials for Soil-Aggregate Subbase, Base, and Surface Courses
3. ASTM D1557 — Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort
4. ASTM D2419 — Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate
5. ASTM D2844/ D2844M — Standard Test Method for Resistance R-Value and Expansion Pressure of Compacted Soils
6. ASTM D3744/ D3744M — Standard Test Method for Aggregate Durability Index
7. ASTM D6913/ D6913M — Standard Test Methods for Particle Size Distribution (Gradation) of Soils Using Sieve Analysis
8. ASTM D6938 — Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

B. State of California, Department of Transportation (Caltrans), Standard Specifications, latest edition:

1. Section 10-6 — Watering
2. Section 26 — Aggregate Bases

1.06 SUBMITTALS

A. General: Refer to Contract Specifications Section 01 33 00, Submittal Procedures, for submittal requirements and procedures.

B. Product Data: Submit source, gradation, R-value, sand equivalent, and durability for the proposed base course material.

C. Test Reports: Submit plant and field test reports as specified in Articles 2.02 and 3.05 herein.

PART 2 – PRODUCTS

2.01 AGGREGATE BASE MATERIAL

A. Aggregates for the two classes of aggregate bases shall conform to the requirements described in the materials section of Caltrans Standard Specifications Section 26-1.02.

B. Aggregate for the two classes of aggregate bases at the time the base material is deposited on the prepared sub grade or sub base shall be free from vegetable matter and other deleterious substances and conform with ASTM D1241.

2.02 SOURCE QUALITY CONTROL

A. The Contractor shall perform sampling and tests of the aggregate base material in accordance with the ASTM D6913/D6913M and tests required in Caltrans Standard Specification Section 26 to determine compliance with specified requirements.

B. Aggregate grading or sand equivalent test shall represent no more than 500 cubic yards of base course material or one day’s production, whichever is the lesser amount.

PART 3 – EXECUTION

3.01 EXAMINATION

A. The Contractor shall call for an inspection by the Engineer and obtain written acceptance of the prepared sub grade or sub base before proceeding with the placement of aggregate base course.

B. The sub grade or sub base to receive aggregate base course, immediately prior to spreading, shall conform to the compaction and elevation tolerances indicated for the material involved and shall be free of standing water and loose or extraneous material.

3.02 INSTALLATION STANDARDS

A. Aggregate base course shall be applied over the prepared sub grade or sub base and compacted in accordance with Section 26 of the Caltrans Standard Specifications.

B. Aggregate base course shall have minimum uniform thickness after compaction of dimensions indicated. Where not indicated, compacted thickness shall be six inches for parking stalls and eight inches for roads, driveways, and aisles of parking areas.

C. All compaction expressed in percentages in this section refers to the maximum dry density as determined by ASTM D1557.

3.03 SPREADING OF MATERIAL

A. Spreading of aggregate base material shall be approved methods and conform to the requirements as described in Section 26 of the Caltrans Standard Specification.

3.04 COMPACTING

A. Compaction of aggregate base material shall be approved methods and conform to the requirements as described in Section 26 of the Caltrans Standard Specification.

3.05 FIELD QUALITY CONTROL

A. The Contractor shall perform field tests in accordance with ASTM D6938 to determine compliance with specified requirements for density and compaction of aggregate base material, and with ASTM D6938 to determine moisture-content compliance of the installed base course.

B. Testing frequency shall be not less than one test for every 2,000 square feet of base course material, per layer or lift.

END OF SECTION 32 11 23

SECTION 32 11 24

AGGREGATE DRAINAGE LAYER

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Aggregate drainage fill.

B. Vapor barrier.

C. Sand cushion.

D. Field quality control.

1.02 RELATED SECTIONS

A. Preparation of sub grade is specified in Contract Specifications Section 31 00 00, Earthwork.

B. Drainage and filter aggregates for subsurface drainage systems are specified in Contract Specifications Section 33 46 00, Subdrainage.

C. Vapor barrier is specified in Contract Specifications Section 07 26 00, Vapor Retarders.

1.03 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for aggregate drainage fill and sand cushion will be by the lump-sum method or by the unit-price method as determined by the listing of the bid item for aggregate drainage fill and sand cushion indicated in the Bid Schedule of the Bid Form.

B. Lump sum: If the Bid Schedule indicates a lump sum for aggregate drainage fill and sand Cushion, the lump sum method of measurement and payment will be in accordance with Contract Specifications Section 01 20 00, Price and Payment Procedures.

C. Unit Price:

1. If the Bid Schedule indicates a unit price for aggregate drainage fill and sand cushion, the unit price method of measurement and payment will be as follows:

    a. Measurement: Aggregate drainage fill and sand cushion, including placement and compaction will be measured for payment by the cubic yard, and quantities will be computed, based on the neat lines or pay lines, section profiles, and dimensions indicated on the Contract Drawings.

b. Payment: Aggregate drainage fill and sand cushion will be paid for at the indicated Contract unit prices for the computed quantities as determined by the measurement method specified in Article 1.03.C. herein.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM C33/ C33M — Standard Specification for Concrete Aggregates
2. ASTM C131/ C131M — Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
3. ASTM C136/ C136M — Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
4. ASTM C144 — Standard Specification for Aggregate for Masonry Mortar
5. ASTM C535 — Standard Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
6. ASTM D4253 — Standard Test Method for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table
7. ASTM D4254 — Standard Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density
8. ASTM D6938 — Standard Test Methods for In-Phase Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

1.05 SUBMITTALS

A. General: Refer to Contract Specifications Section 01 33 00, Submittal Procedures, and Contract Specifications Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Samples: Submit a 10-pound cloth bag of clean and graded aggregates proposed for the aggregate drainage fill for approval.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Aggregate Drainage Fill:

1. Aggregate drainage fill for capillary break under concrete slabs shall consist of broken stone, crushed or uncrushed gravel, clean quarry waste, or a combination thereof, free from adobe, vegetable matter, loam, volcanic tuff, and other deleterious substances. It shall be of such quality that the absorption of water in a saturated surface dry condition does not exceed three percent of the oven dry weight of the samples.

2. Aggregate drainage fill shall be of such size that the percentage composition by dry weight as determined by laboratory sieves (U.S. Series) will conform to the following grading when measured in accordance with ASTM C136/C136M:

Sieve Size	**Percentage Passing Sieves**
1-1/2 inches	100
1 inch	90-100
No. 4	0-5

3. Percentage wear when tested in accordance with ASTM C131/C131M and ASTM C535 shall be 50 percent maximum.

B. Vapor Barrier Materials: Refer to Contract Specifications Section 07 26 00, Vapor Retarders, for requirements.

C. Sand Cushion: Sand for sand cushion or blanket under slabs and over vapor barrier shall be a clean and graded, washed sand, all passing a No. 4 U.S. Standard Sieve, and conforming generally to ASTM C33/C33M for fine aggregate. Clean masonry aggregate conforming to ASTM C144 is also acceptable.

PART 3 – EXECUTION

3.01 EXAMINATION

A. The Contractor shall call for an inspection by the Engineer and obtain written approval of the prepared sub grade or sub base before proceeding with placing of the aggregate drainage fill.

B. The sub grade or sub base to receive aggregate drainage fill shall conform to the compaction and elevation tolerances indicated for the material involved and shall be free of standing water and loose or extraneous material.

3.02 INSTALLATION

A. Aggregate Drainage Fill:

1. Pipes, drains, conduits, and any other mechanical or electrical installations shall be in place before any aggregate drainage fill is placed. Backfill at walls to elevation of drainage fill shall be in place and compacted.

2. Aggregate drainage fill under concrete slabs shall be the minimum uniform thickness after compaction of dimensions indicated. Where not indicated, minimum thickness after compaction shall be four inches.

3. Aggregate drainage fill shall be compacted with appropriate compaction equipment to form a well-compacted bed. Provide for relative density of 75 percent as determined by ASTM D4253, Dry Method, and ASTM D4254, Method A.

4. Heavy equipment shall not be used within four feet of concrete walls. Instead, aggregate drainage fill shall be compacted with suitable light equipment, such as hand-held mechanical tampers.

5. The Contractor shall have the Engineer inspect and approve the finished aggregate drainage fill before proceeding with any subsequent construction over the compacted fill.

B. Vapor Barrier Installation: Lay vapor-barrier membrane over the compacted aggregate drainage fill as specified in Contract Specifications Section 07 26 00, Vapor Retarders.

C. Sand Cushion: A sand cushion shall be placed over the vapor barrier membrane under concrete building slabs on grade. Sand cushion shall be placed in uniform thickness indicated. Where not indicated, thickness shall be two inches.

3.03 FIELD QUALITY CONTROL

A. The Contractor shall perform field tests in accordance with ASTM D6938 to determine compliance with specified requirements for density and compaction of the installed aggregate drainage fill.

END OF SECTION 32 11 24

SECTION 32 12 16

ASPHALT PAVING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Placing of base course.

B. Placing of asphalt concrete.

C. Sealant.

D. Field quality control.

E. Maintenance of pavement.

F. Repair of asphalt pavement.

1.02 RELATED SECTIONS

A. Preparation of sub grade to proper grade for base course, including compaction, is specified in Contract Specifications Section 31 00 00, Earthwork.

B. Preparation of subbase and base, where required, is specified in Contract Specifications Section 32 11 17, Aggregate Subbase Courses, and Contract Specifications Section 32 11 23, Aggregate Base Courses, respectively.

C. Portland cement concrete paving is specified in Contract Specifications Section 32 13 13, Concrete Paving.

D. Painting of stripes and other markings on pavement is specified in Contract Specifications Section 32 17 23, Pavement Marking.

E. Portland cement concrete curbs and gutters are specified in Contract Specifications Section 32 16 21, Concrete Curbs, Gutters, and Walks.

1.03 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for asphaltic concrete paving will be by the lump-sum method or by the unit-price method as determined by the listing of the bid item for asphaltic concrete paving indicated in the Bid Schedule of the Bid Form.

B. Lump sum: If the Bid Schedule indicates a lump sum for asphaltic concrete paving, the lump-sum method of measurement and payment will be in accordance with Contract Specifications Section 01 20 00, Price and Payment Procedures.

C. Unit Price:

1. If the Bid Schedule indicates a unit price for asphaltic concrete paving, the unit price method measurement and payment will be as follows:

   a. Measurement:

      1) Asphaltic concrete pavement will be measured for payment by the square yard for each different thickness of pavement placed in the work. The quantity for pavement will be the square area placed at the indicated thickness, based on the dimensions, neat lines or pay lines, and sections indicated on the Contract Drawings.

      2) Asphaltic prime and tack coats, pavement reinforcing fabric, and seal coat will not be measured separately for payment, but will be considered included in the square yard measurement for the asphaltic concrete pavement.

      3) Measurement of the aggregate base course is specified in Contract Specifications Section 32 11 23, Aggregate Base Courses. Measurement of the aggregate subbase course is specified in Contract Specifications Section 32 11 17, Aggregate Subbase Courses.

   b. Payment: Asphaltic concrete paving will be paid for at the indicated Contract unit prices for the computed quantities as determined by the measurement method specified in Article 1.03C., herein.

1.04 REFERENCES

A. State of California, Department of Transportation (Caltrans), Standard Specifications, latest edition:

1. Section 37 Bituminous Seals
2. Section 39 Asphalt Concrete
3. Section 92 Asphalt Binders
4. Section 94 Asphaltic Emulsions
5. Section 96 Geosynthetics

B. State of California, Department of Transportation (Caltrans), Standard Test Methods:

1. Calif. Test 202 Method of Tests for Sieve Analysis of Fine and Coarse Aggregates
2. Calif. Test 375 Determining the in Place Density and Relative Compaction of Hot Mix Asphalt Pavement Using Nuclear Gages
3. Calif. Test 379 Method of Determining Asphalt Content of Bituminous Mixtures by Use of the Nuclear Gage

4. Calif. Test 382 Method of Test for Determination of Binder Content of Hot Mix Asphalt by the Ignition Method

1.05 REGULATORY REQUIREMENTS

A. Asphaltic products and solvents shall be compliant with the latest regulations of the Bay Area Air Quality Management District regarding regulations governing permissible content of volatile organic compounds (VOC).

1.06 SUBMITTALS

A. General: Refer to Contract Specifications Section 01 33 00, Submittal Procedures, for submittal requirements and procedures.

B. Mix Design: Submit proposed mix design for each asphaltic concrete mixture and seal coat to be used in the work, covering the specific materials to be used in the mixes. Include test data in support of each proposed mix design.

C. Test Reports: Submit test results of sampling and testing, and inspection records within 24 hours of asphaltic concrete placement.

1.07 PROTECTION

A. Protect concrete pavements and walks, curbs and bases, and other improvements adjacent to the operations with suitable materials. The Contractor shall be responsible for any damage caused by the Contractor's employees or equipment and shall make necessary repairs. Buildings and other surfaces shall be covered with paper or other protection, where required. All damage caused by the Contractor's operations shall be repaired or replaced as required.

1.08 PROJECT ENVIRONMENT REQUIREMENTS

A. Work shall comply with construction requirements listed in Caltrans Standard Specifications Section 39-2.01C and not be performed under the following conditions:

1. Ambient, base or pavement temperature below 50 degrees Fahrenheit

2. Over-saturated base and subbase material. Base and subbase to be wheel-rolled by loaded water truck to determine any yielding. If deflection is observed, do not perform paving until grade is stable and unyielding and conforming to compaction requirements.

PART 2 – PRODUCTS

2.01 BASE COURSE MATERIAL

A. Class 3 Aggregate Base mineral aggregate as specified in Contract Specifications Section 32 11 23, Aggregate Base Courses.

2.02 TACK COAT

A. Tack Coat: Diluted SS-1 or SS-1h emulsion in conformance with Section 94 of the Caltrans Standard Specifications.

2.03 PAVEMENT REINFORCING FABRIC

A. Pavement reinforcing fabric in conformance with Section 96 of the Caltrans Standard Specifications.

2.04 ASPHALT PAVING MATERIALS

A. Hot Mix Asphalt: Type A, with the gradation of the combined aggregate conforming to one-half inch maximum size, or three-fourth inch maximum size, as indicated, and as specified in Section 39 of the Caltrans Standard Specifications. Unless shown otherwise, top two-inch lift shall be one-half inch maximum size.

B. Asphalt Binder: Performance Grade asphalt binder, in accordance with Section 92 of the Caltrans Standard Specifications.

C. Mixing Facilities: Asphalt concrete surfacing material shall be furnished from an approved commercial asphalt central mixing plant.

2.05 BITUMINOUS SEAL

A. Bituminous seal, as indicated, in conformance with Section 37 of the Caltrans Standard Specifications.

2.06 MIX DESIGN

A. Design of asphaltic concrete mixes shall be provided by the Contractor, and shall be obtained from a qualified independent testing laboratory or agency, properly equipped to design asphaltic concrete mixes. Costs of obtaining mix designs shall be at the Contractor’s expense.

B. Design of asphaltic concrete mixes, including aggregate quality and gradation, shall conform with the quality requirements of Section 39 of the Caltrans Standard Specifications.

2.07 SOURCE QUALITY CONTROL

A. The Contractor shall perform sampling and tests of materials in accordance with the following requirements:

1. Aggregate Grading: The combined aggregate, prior to addition of asphalt binder (paving asphalt), shall conform with the “Operating Range” requirements specified in Section 39 of the Caltrans Standard Specifications for the type of aggregate specified herein. Conformance with grading requirements shall be determined by California Test Method (CTM) 202.

2. Frequency of Tests: Minimum testing frequency shall be one test for every 500 tons, or fraction thereof, for each graded aggregate placed each day.

3. Asphalt Content: Asphalt content shall be within plus or minus 0.50 percent of the mix design content. Conformance with asphalt content requirements shall be determined by CTM 382 or 379 from samples taken from the mat behind the paving machine. Minimum testing frequency shall be one test for every 500 tons, or fraction thereof, for each asphaltic paving mix placed each day.

PART 3 – EXECUTION

3.01 PLACING OF BASE COURSE

A. The Contractor shall call for an inspection by the Engineer and obtain written approval of the sub grade before proceeding with the base course.

B. Base course shall be placed over finished sub grade with compacted thickness in accordance with Contract Specifications Section 32 11 23, Aggregate Base Courses.

C. After base course has been completed, the Contractor shall call for an inspection by the Engineer and obtain written approval before proceeding with application of the asphalt-wearing surface.

3.02 PLACING ASPHALT CONCRETE

A. Areas to be paved shall be covered with a layer of hot asphalt concrete surfacing not less than the thickness indicated after compaction. Where not indicated, compacted thickness shall be a minimum of four inches.

B. Paving asphaltic concrete shall be delivered, laid, rolled, and finished in accordance with Section 39 of the Caltrans Standard Specifications.

C. Before placing asphalt concrete on untreated base, a liquid asphalt prime coat shall be applied to the base course in the areas to be surfaced in accordance with Section 39-4 of the Caltrans Standard Specifications. Prime coat shall be applied at the rate of 0.25 gallons per square yard.

D. Pavement reinforcing fabric shall be embedded in the liquid prime coat in accordance with Section 39 of the Caltrans Standard Specifications.

E. Before placing asphalt concrete, a tack coat (paint binder) shall be applied to all vertical surfaces against which asphalt concrete surfacing will be placed. Tack coat (paint binder) shall be applied in accordance with Section 39-4 of the Caltrans Standard Specifications at the rate of from 0.02 to 0.10 gallons per square yard.

F. Where cold joints are indicated or necessary, cut back the placed and compacted cold asphalt a minimum of three inches with a concrete or masonry power saw, so that a vertical face of compacted full thickness material is exposed. Treat this surface with a tack coat before proceeding with the placement of new asphaltic concrete surfacing.

G. Finish paving shall conform to finish elevations within plus or minus 0.01 of a foot and shall be level to within plus or minus one-fourth inch in ten feet when measured with a 10-foot straightedge in any direction.

H. Joints shall be heated if laid more than 3 hours previously.

I. Initial compaction rolling shall occur when mix cools below 250 degrees Fahrenheit.

J. Provide and roll 1/4 inch lip above adjoining Portland cement concrete surfaces.

3.03 BITUMINOUS SEAL

A. Apply bituminous seal over finished paving surface in conformance with Section 37 of the Caltrans Standard Specifications.

3.04 FIELD QUALITY CONTROL

A. The Contractor shall control the quality of the Work and shall provide adequate testing to assure compliance with these Specifications herein.

B. After completion of paving work, all paving shall be flooded with water, and any resulting “ponds” shall be ringed with chalk. Such hollows shall be corrected with addition of asphalt paving materials and re-rolling until all paving is completely level and free from hollows and high spots.

C. The Contractor shall perform in-place density and compaction tests of the completed pavement in accordance with CTM No. 375 to determine compliance with specified requirements. Relative compaction shall be between 92-96 percent. Test density core for each 250 tons of HMA. Maximum area size shall be 500 tons with a minimum of 3 tests per location, and 1 test for each 50 tons after. Each pavement area shall be an independent lot. Compaction shall be taken as the average for a pavement area. If compaction does not comply, Engineer may accept HMA and take payment deduction as shown in table for reduced payment factors for Caltrans Standard Specifications Section 39-2.01A.

D. Hot mix asphalt arriving at project site below 260 degrees Fahrenheit shall be rejected.

3.05 MAINTENANCE OF PAVEMENT

A. Upon completion of final rolling, traffic shall not be permitted on the finished pavement for at least six hours, and until the asphalt concrete has cooled sufficiently to withstand traffic without being deformed.

B. Finished pavement shall be maintained in finished clean condition until the Work is accepted by the Engineer.

3.06 REPAIR OF ASPHALT PAVEMENT

A. Repair shall be as follows:

1. Sawcut vertical edges of pavement in rectangular shape 1 foot minimum beyond damaged material.

2. Provide base material per Contract Drawings and Contract Specifications Section 32 12 16, Asphalt Paving, herein.

3. Apply tack coat to vertical faces of adjoining asphalt and concrete.

4. Paving lifts shall be a single lift if less than 3.5 inches depth. If four or more inches, place in lifts of 3 inches maximum and minimum of 2 inches for top lift. Paving and compaction shall comply with requirements as described previously. Heat cold joints of adjacent existing pavement if placed over 3 hours prior to place on new asphalt.

END OF SECTION 32 12 16

SECTION 32 12 36

ASPHALT EMULSION SEALER

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Environmental Conditions.

B. Placement of Sealer.

1.02 RELATED SECTIONS

A. Asphalt paving and repair is specified in Contract Specifications Section 32 12 16, Asphalt Paving.

1.03 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for asphalt emulsion sealer will be by the lump-sum method or by the unit-price method as determined by the listing of the bid item for asphalt emulsion sealer indicated in the Bid Schedule of the Bid Form.

B. Lump Sum: If the Bid Schedule indicates a lump-sum for concrete reinforcement, the lump-sum method of measurement and payment will be in accordance with Contract Specifications Section 01 20 00, Price and Payment Procedures.

C. Unit Price:

1. If the Bid Schedule indicates a unit price for concrete reinforcement, the unit-price method of measurement and payment will be as follows:

    a. Measurement: Asphalt emulsion sealer will be measured for payment by the ton or square foot, as designated in the Contract item, for each type of asphalt emulsion sealer placed in the Work.

    b. Payment: Asphalt emulsion sealer will be paid for at the indicated Contract unit prices for the computed quantities as determined by the measurement method specified in Article 1.03.C herein.

1.04 REFERENCES

A. State of California, Department of Transportation (Caltrans) Standard Specifications, latest edition:

1. Section 37 Bituminous Seals

1.05 TYPES OF ASPHALT EMULSION SEALER

A. Asphalt emulsion sealers are designated as Seal Coats and Slurry Seal. Type of Sealer shall be as indicated as in Contract Documents.

1.06 SUBMITTALS

A. General: Refer to Contract Specification Section 01 33 00, Submittal Procedures, for submittal requirements and procedures.

B. Emulsion Sealer: Submit product datasheet and manufacturer's application recommendations.

1.07 ENVIRONMENTAL CONDITIONS

A. Apply sealer at ambient temperatures between 60 and 100 degrees Fahrenheit.

B. Do not apply sealer on wet pavement or if precipitation is forecasted.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Seals and Coats: Products shall comply with requirements in Caltrans Standard Specifications Section 37.

B. Aggregate: Material shall be clean, free of silt, clay, salts and organic matter and comply with Aggregate Gradation Requirements in Caltrans Standard Specifications Section 37.

PART 3 – EXECUTION

3.01 PREPARATION

A. Preparation of surface shall comply with Caltrans Standard Specifications Section 37.

B. Protect existing posts, landscaping, curbs and gutters, sidewalks, buildings, and other facilities from discoloration from splashing asphalt emulsion sealer. Stained surfaces shall be painted or repaired at no cost to the District.

3.02 APPLICATION

A. Application of asphalt emulsion sealer shall comply with Caltrans Standard Specifications Section 37.

3.03 PROTECTION

A. Protect applied asphalt emulsion sealer by keeping traffic off of freshly applied sealer for 24 hours minimum or per manufacturer's recommendation, whichever is longer.

END OF SECTION 32 12 36

SECTION 32 13 13

CONCRETE PAVING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Materials and accessories.

B. Preparation of subgrade, subbase, or base.

C. Formwork.

D. Placing concrete reinforcement.

E. Placing concrete.

F. Joints.

G. Finishing.

H. Curing and protection.

I. Installation of joint seals.

J. Field quality control.

1.02 RELATED SECTIONS

A. Preparation of subgrade to proper grade for concrete, including compaction, is specified in Contract Specifications Section 31 00 00, Earthwork.

B. Preparation of subbase and base, where required, is specified in Contract Specifications Section 32 11 17, Aggregate Subbase Courses, and Contract Specifications Section 32 11 23, Aggregate Base Courses, respectively.

C. Portland cement concrete curbs and gutters are specified in Contract Specifications Section 32 16 21, Concrete Curbs, Gutters, and Walks.

D. Portland cement concrete, concrete reinforcement, and various materials, services, and incidentals pertaining thereto shall conform with Contract Specifications Section 03 20 00, Concrete Reinforcing, Contract Specifications Section 03 15 00, Concrete Accessories, Contract Specifications Section 03 30 00, Cast-In-Place Concrete, Contract Specifications Section 03 05 15, Portland Cement Concrete, and Contract Specifications Section D, 03 35 00, Concrete Finishing.

E. Requirements for tack coat is specified in Contract Specifications Section 32 12 16, Asphalt Paving.

1.03 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for portland cement concrete paving will be by the lump-sum method or by the unit-price method as determined by the listing of the bid item for portland cement concrete paving indicated in the Bid Schedule of the Bid Form.

B. Lump sum: If the Bid Schedule indicates a lump sum for portland cement concrete paving, the lump-sum method of measurement and payment will be in accordance with Contract Specifications Section 01 20 00, Price and Payment Procedures.

C. Unit Price: If the Bid Schedule indicates a unit price for portland cement concrete paving, the unit-price method of measurement and payment will be as follows:

1. Measurement:

   a. Portland cement concrete pavement will be measured for payment by the square yard for each specified class of concrete and thickness.

   b. Reinforcing steel, dowels, and tie bars placed with work will be measured separately for payment as specified in Contract Specifications Section 03 20 00, Concrete Reinforcing.

   c. Subgrade paper, transverse expansion joints, weakened-plane joints, and joints sawed within 5 feet of volunteer cracks, longitudinal and transverse construction joints, and longitudinal weakened-plane joints will not be measured separately for payment, and all costs in connection therewith will be considered included in the measurement of portland cement concrete pavement.

2. Payment: Portland cement concrete paving will be paid for at the indicated Contract unit prices for the computed quantities as determined by the measurement method specified in Article 1.03.C., herein.

1.04 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):

1. AASHTO M81 Cut-Back Asphalt (Rapid-Curing Type)

B. American Concrete Institute (ACI):

1. ACI 117 Specification Tolerances for Concrete Construction and Materials and Commentary

2. ACI 318 Building Code Requirements for Structural Concrete and Commentary

C. American Society for Testing and Materials (ASTM):

1. ASTM A53/ A53M Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

2. ASTM A615/ A615M — Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement

3. ASTM A663/ A663M — Standard Specification for Steel Bars, Carbon, Merchant Quality, Mechanical Properties

4. ASTM C39/ C39M — Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

5. ASTM C309 — Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete

6. ASTM C496/ C496M — Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens

7. ASTM D2628 — Standard Specification for Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements

D. Federal Specifications (FS):

1. UU-B-790 — Building Paper, Vegetable Fiber, (Kraft, Waterproofed, Water Repellent, And Fire Resistant)

E. State of California, Department of Transportation (Caltrans), Standard Specifications, latest edition:

1. Section 40 — Concrete Pavement

1.05 SUBMITTALS

A. General: Refer to Contract Specifications Section 01 33 00, Submittal Procedures, and Contract Specifications Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Product Data: Submit the respective manufacturer’s product data for manufactured products.

C. Shop Drawings:

1. Submit drawings that indicate the locations of all joints in concrete, including construction joints, expansion joints, isolation joints, and weakened-plane or contraction joints.

2. Submit drawings of reinforcing steel, tie bars, and connecting dowels. Comply with requirements specified in Contract Specifications Section 03 20 00, Concrete Reinforcing.

1.06 QUALITY ASSURANCE

A. Tolerances: Comply with requirements of ACI 117, Section on Pavements.

PART 2 – PRODUCTS

2.01 FORMS

A. Provide metal forms, weighing not less than 18 pounds per linear foot for pavement 8 inches thick, not less than 20 pounds per linear foot for pavement 9 inches thick, and not less than 22 pounds per linear foot for pavement 10 inches thick, and in no case less than 7/32 inch thick.

B. Provide side forms having a depth equal to the prescribed edge thickness of the pavement, without horizontal joints.

C. Provide forms having a base not less than eight inches wide and a flanged tread or top surface not less than two inches wide. For multiple lanes, provide base width at least equal to height.

D. Provide forms not less than ten feet long except where shorter forms are necessary for curves. Use metal keyway forms for the full length of roadway form to which attached. Provide wood bulkheads for the full width of pavement lane equipped with keyway form.

E. Provide holes for bars and dowel assemblies where required.

F. Provide at least three stake pockets to accommodate a one inch diameter stake in each section of form ten feet or more in length, and at least two such pockets in each section of form less than ten feet long.

G. Provide each section of form with a positive locking device that will secure it tightly to the adjoining section.

H. Provide forms free from warp and of sufficient strength to resist, without visible springing or settlement, all loads applied in the paving process.

2.02 MATERIALS AND ACCESSORIES

A. Concrete Reinforcement: Refer to Contract Specifications Section 03 20 00, Concrete Reinforcing, for requirements.

B. Portland Cement Concrete: Refer to Contract Specifications Section 03 05 15, Portland Cement Concrete, for requirements. Provide class of concrete as indicated on the Contract Drawings.

C. Liquid Asphalt: AASHTO M81, cut-back asphalt, rapid-curing type.

D. Subgrade Paper: Kraft laminated building paper with bituminous binder, reinforced, meeting requirements of FS UU-B-790.

E. Benches and Chairs: ACI 318.

F. Tie Bars: ASTM A615/A615M, Grade 60, of type and size indicated.

G. Dowels: Plain round bars meeting requirements of ASTM A615/A615M, Grade 60, or ASTM A663/A663M, Grade 80, epoxy-coated bars, furnished with approved snug-fitting ASTM A53/A53M galvanized pipe sleeve. Provide sleeve with one end closed.

H. Expansion-Joint Filler: ASTM D2628, preformed elastomeric joint seal.

I. Joint Sealing Compound: Refer to Contract Specifications Section 03 15 00, Concrete Accessories, for requirements.

J. Concrete Curing Compound: ASTM C309, Type 1.

PART 3 – EXECUTION

3.01 PREPARATION OF SUBGRADE, SUBBASE, OR BASE

A. Immediately prior to placing forms, condition and trim subgrade, subbase, or base to exact shape, grade, and cross section required by the Contract Drawings. Condition and shape to indicated width between side forms plus not less than one extra foot on each side.

B. Use of a subgrade machine of approved type is permitted, in which case place forms in advance of exact conditioning and trimming, to permit use of the machine.

C. Where the crown is to be warped or sloped to conform to contour of intersecting streets, storm water inlets, and other intersecting contoured surfaces, shape subgrade to required depth and cross section by means of hand tools and other equipment as approved by the Engineer. In addition:

1. Drive grade stakes to proper elevation in the subgrade at six-foot intervals in both directions.

2. Compact subgrade by rolling at least one foot wider on each side than the concrete.

3. Finish concrete in such locations by means of floats, shovels, spades, or other approved hand tools, operated so as to consolidate the concrete without segregation.

D. Deposit any excess material obtained from such preparations upon adjacent shoulders or as required.

E. Prepare subbase, if required, as specified in Contract Specifications Section 32 11 17, Aggregate Subbase Courses.

F. Prepare base, if required, as specified in Contract Specifications Section 32 11 23, Aggregate Base Course.

3.02 FORMWORK

A. Obtain written approval from the Engineer of the subgrade, subbase, or base prior to placing forms and impervious compacted subgrade.

B. Place subgrade paper where indicated.

C. Do not use built-up forms. Remove forms with battered top surfaces, distorted faces or bases, and forms that are deformed or broken in any way; and, if straightened and repaired, do not reuse until they have been inspected and approved in writing by the Engineer.

D. Do not use forms showing a variation of more than 1/8 inch in a ten-foot length from the plane of the top or face when tested with a straightedge.

E. Join forms neatly and tightly and stake securely with stakes in every pocket. Drive up fully all locking devices at form joints so as to produce a smooth fitting, rigid joint.

F. Maintain proper grade and alignment under all working conditions. Maintain base of forms directly in contact with the finished subgrade, base, or subbase.

G. Building of pedestals of earth or other materials upon which to rest forms in order to bring them to the required grades will not be permitted.

H. Clean and coat forms with form release compound before concrete is placed against them, each time they are used.

I. Do not remove forms from freshly placed concrete until the concrete has set for 12 hours.

J. District Representative shall approve of formwork prior to placing concrete.

3.03 PLACING CONCRETE REINFORCEMENT

A. When reinforcement is indicated, provide deformed bars, welded wire fabric, or prefabricated welded or clipped deformed bar mats, as indicated on the Contract Drawings, and of size and quantity indicated.

B. Place reinforcement so that the extreme longitudinal member will be located not more than three inches from the sides of the slab section, and extend the end of all longitudinal members to within two inches of the ends of slab sections.

C. Lap adjacent sheets of welded wire fabric and welded or clipped mats not less than 12 inches when the lap is made at right angles to the centerline of the pavement and where wire fabric sheets are permitted to be lapped parallel to the centerline.

D. Wrap the wire fabric or bar mats together with wire at all laps, at intervals not exceeding 24 inches.

E. Reinforce multiple lane construction with bar mats or sheets of welded wire fabric of same weight and size as though the paving were constructed in single lane widths. Install mats or sheets to leave an unreinforced longitudinal gap six inches wide, parallel to and centered on the lane lines.

F. Place tied bars or prefabricated bar-mat reinforcement securely supported on approved chairs as specified in Contract Specifications Section 03 20 00, Concrete Reinforcing, and ACI 318. Install reinforcement in place on supports on the subgrade for a distance ahead of the paver equal to at least 500 feet or a two-hour run of the paver, whichever is greatest, before any paving is begun. Stop paving and install a bulkheaded construction joint whenever the paver comes to within 100 feet of the end of such steel placement. Secure reinforcement against displacement during concrete placement.

G. Tie Bars and Dowels:

1. Uniformly place tie bars and dowel assemblies at the indicated depth below finished surface on four-foot centers or other dimensions where indicated otherwise on the Contract Drawings.

2. In all of the above methods of reinforcement placement, install dowel bar assemblies and secure in place in metal chairs on the subgrade, ahead of the placement of the slab reinforcement and concrete.

3. Support tie bars for weakened-plane joints on metal chairs and securely fasten prior to placing concrete, or place on top of the freshly poured concrete and vibrate to position at proper depth. Install tie bars in such manner that upon initial set of the concrete they will be at proper alignment, depth and spacing, and at right angles to the designated line of cut.

4. Place tie bars for construction joints on metal chairs, or machine place, in such a manner that upon the initial set of the concrete, they will be at proper alignment, depth, and spacing, and at right angles to the formed edge of the joint.

3.04 PLACING CONCRETE

A. Notify the Engineer at least 24 hours in advance of placing concrete.

B. In the event completion of concrete placement during darkness should become necessary, provide a lighting system adequate to illuminate all concrete-placement operations.

C. An interval of more than 45 minutes between placing of two consecutive concrete batches will be cause for stopping paving operations. Should this occur, place a bulkhead with construction joint keyway.

D. Place concrete while fresh. Retempering of concrete will not be not permitted.

E. Do not chute concrete directly on to subgrade or subbase from any type of hauling unit without written permission from the Engineer.

F. Place concrete pavement in full traffic lane widths, separated by construction joints; or if approved, the concrete pavement may be placed monolithically, two or more traffic lanes wide without a construction joint, but with a longitudinal weakened-plane joint at each traffic lane line.

G. Deposit concrete in successive batches on the subgrade or subbase to full width of traffic lane and strike off with an approved screed-type finishing machine.

H. When constructing adjacent traffic lanes, the wheels of the finishing machine that rest on previously completed concrete shall be flat, without flanges, and the inside edge of the tread of the wheels shall not operate so close to edge of slab as to cause spalling or damage. The tread of the wheels shall not be less than three-inches in width. The wheels on the opposite side, that operate on the steel side forms, shall have flanges on both sides.

I. Use a mechanical spreader of an approved type, designed to move the volume of freshly deposited concrete transversely.

J. Use concrete already placed in adjacent traffic lane, curb, or gutter as the form for new concrete placed adjacent thereto, but not until the concrete placed in the first lane has attained a split tensile strength of at least 300 pounds per square inch, as determined by ASTM C496/C496M.

K. Consolidate concrete by means of suitable vibrating screed, internal vibrator, or other approved vibratory equipment such that the concrete is effectively consolidated without segregation. Maintain amplitude of vibration such that the vibrations are perceptible on the surface of the concrete at least one foot from the vibrating equipment. Provide a device for measuring and indicating the actual frequency of vibrations.

L. Perform screeding and tamping by making one complete pass over the entire area of the pavement. Adjust the tamper to produce the proper tamping action and adjust screeds to an elevation slightly above finished grade, so that when properly consolidated and finished, the completed surface of the pavement will be at the required grade, true to cross section indicated, and free from laitance and porous areas.

M. Concrete required to be placed in widths less than a normal traffic lane may be compacted and shaped by a powered mechanical compacting and shaping machine supplemented by hand methods as necessary. Deposit concrete as nearly as possible in its final position. Do not use vibrators for extensive shifting of masses of fresh concrete.

3.05 JOINTS

A. General:

1. Joints in pavement are designated as longitudinal and transverse construction joints, transverse expansion joints, and longitudinal and transverse weakened-plane joints.

2. Construct the faces of all joints normal to the finished surface of the road.

3. Construct transverse joints normal to the centerline of the road and extending full width of pavement. Construct similar types of transverse joints in line with each other across the full width of the pavement.

4. Construct longitudinal joints coincident with or parallel to the pavement centerline.

5. Install load transfer devices parallel to finished surface of the road.

6. Maintain finished surface of concrete in the same plane on both sides of a joint.

7. Apply curing compound No. 1 or 2 on surfaces between fresh and hardened concrete.

B. Construction Joints:

1. Construction joints shall be made when placing fresh concrete against hardened concrete at planned locations and elsewhere when concreting is interrupted for longer than 45 minutes.

2. Connect concrete on both sides of longitudinal construction joints with tie bars as indicated.

3. Do not place transverse construction joints within ten feet of any other transverse joint. Should it become necessary to stop concreting for a period of time sufficient to require the installation of a bulkhead and construction joint within ten feet of an existing transverse joint, remove and waste the concrete that has been placed beyond the existing joint.

C. Transverse Expansion Joints:

1. Form transverse expansion joints at indicated locations by means of preformed expansion joint filler. Support the joint strips in position by means of metal holders and end supports. Hold the supports firmly in position during concreting, and maintain them in place after completion of pavement.

2. Use metal holders fabricated of minimum 16-gage sheet steel in the form of a deep channel extending not less than 4 inches downward on both sides of the joint strip, slotted and cut away as necessary to allow the concrete to make close contact with the joint strip at close intervals. Spread ends of holders to admit the end supports.

3. During placement and consolidation of concrete, secure joint holder and end supports so as to prevent movement of the joint strip and to keep the top edge of the joint strip approximately 1/2 inch below the surface of finished pavement. After concrete has been placed and consolidated, the metal holder may be removed and a suitable metal channel substituted therefore; fit the channel snugly over the top edge of the joint strip and maintain it there until the joint is edged.

4. After side forms are removed, remove concrete that has flowed around the ends of the joint filler.

D. Weakened-Plane Joints:

1. Construct weakened-plane joints with a power concrete or masonry saw to a depth of not less than two inches and a width of 1/4 inch, plus or minus 1/16 inch. Produce clean cuts with sharp edges and no dislocation of coarse aggregate.

2. Saw weakened-plane joints not less than 12 hours nor more than 24 hours after placing concrete, unless otherwise approved by the Engineer. Conduct night operations if necessary to meet these time limits. Maintain a stand-by power concrete saw on the site at all times when paving operations are under way.

3. Do not saw where volunteer transverse cracks exist. If a volunteer transverse crack exists within five feet of a planned, sawed joint, omit the sawed joint, but do not omit more than three consecutive planned, sawed joints.

4. Restore curing compound disturbed by sawing operations. Conduct sawing operations in such a manner that the surface and edges of pavement will be unprotected for not more than 20 minutes.

5. At the Contractor's option, longitudinal weakened-plane joints at traffic lane lines in multilane monolithic concrete pavement may be formed by placing a continuous strip of plastic or other approved material that will not react adversely with the concrete. Use joint insert material of such width and character that, when placed vertically in the concrete, it will not bond with the concrete and will form an effective weakened-plane joint not less than two inches deep.

6. Insert the joint material with a mechanical device that places the material in a continuous strip, except where intervening structures break the continuity of paving. Splices in joint material will be permitted if splices are effective in maintaining the continuity of the joint material as placed.

7. Maintain top of joint material not more than 1/8 inch below finished surface of concrete. Do not deform joint material from a vertical position. Maintain alignment of finished joint parallel with center line of pavement, and free of local irregularities that exceed 1/2 inch, measured by a 12 foot straightedge, except for normal curvature of center line alignment.

8. Use a mechanical installation device to vibrate the concrete during placement of the strip, to cause the concrete to flow evenly about the joint material.

9. On completion of joint sawing, or on removal of the optional joint insert material, clean the joint and remove moisture by blowing with compressed air if necessary. Fill the joint with joint sealing compound in accordance with the manufacturer's instructions.

3.06 FINISHING

A. Following placing of concrete, and after it has been screeded with a transverse finishing machine, screed longitudinally with a power-operated longitudinal finishing machine of an approved type. Work longitudinal screed cross-wise so as to level any irregularities in the surface.

B. Following longitudinal screed, use an approved scraping strike off for removing any accumulation of excess mortar, laitance, or inert material from the surface.

C. For the final finish, drag surface with a single full width strip of burlap to produce a uniform gritty texture on the surface. Keep burlap wet and periodically wash out to remove accumulations of mortar.

D. After burlap dragging has been completed and concrete has taken its initial set, use an edging tool with 1/4 inch radius along each edge of the surface to prevent chipping of the edges in the removal of forms. Tool in same manner the longitudinal edge of any concrete surface adjoining previously placed pavement, to avoid subsequent spalling. Edge all joints at the same time, working from suitable bridges. Take particular care to keep surface of concrete in the same plane on both sides of each joint. Kneeling planks will not be permitted on the concrete surface.

E. Where special circumstances require, hand float finishing may be substituted for a finishing machine, providing the following requirements are met:

1. Use float of approved design and construction to provide a true floated surface.

2. Operate each float from the side of the pavement and parallel to the centerline of the pavement.

3. Use edge of float to cut down high areas. Float removed material into depressions until a true surface is obtained.

4. On each successive passage of the float, slightly lap the previous path; and, upon completion of each passage, bring the float back and smooth the overlap between the two passages.

5. Operate floats as far back of tamping machine as the concrete remains workable, with sufficient passes to remove perceptible irregularities.

6. Maintain at least one spare float in good condition and available on the worksite at all times.

3.07 CURING AND PROTECTION

A. Comply with the applicable requirements of Contract Specifications Section 03 35 00, Concrete Finishing, for curing concrete with liquid membrane-forming curing compound. Do not permit traffic on new concrete pavement until the concrete has attained its 28-day compressive strength as determined by strength tests in accordance with ASTM C39/C39M.

3.08 INSTALLATION OF JOINT SEALS

A. Install joint fillers and sealing compounds where indicated in accordance with applicable requirements of Contract Specifications Section 03 15 00, Concrete Accessories.

3.09 FIELD QUALITY CONTROL

A. Strength Tests: The Contractor shall perform strength tests of concrete as specified in Contract Specifications Section 03 05 15, Portland Cement Concrete.

B. Thickness: After pavement is placed and cured, the Contractor shall take core samples at locations designated by the Engineer, for determination of actual thickness. A minimum of one core sample shall be obtained from each 100 feet of roadway for each lane.

3.10 CORRECTING NON-COMPLIANT PAVEMENT WORK

A. Procedure for correcting non-compliant pavement work shall comply with requirements for Caltrans Standard Specifications Section 40.

END OF SECTION 32 13 13

SECTION 32 16 21

CONCRETE CURBS, GUTTERS, AND WALKS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Materials and accessories.

B. Preparation of sub grade.

C. Types of construction.

D. Joints.

E. Form removal.

F. Finishing.

G. Curing and protection.

H. Detectable warning surface.

I. Existing curbs and sidewalks.

J. Field quality control.

1.02 RELATED SECTIONS

A. Preparation of sub grade to proper grade for concrete, including compaction, is specified in Contract Specifications Section 31 00 00, Earthwork.

B. Portland cement concrete, concrete reinforcement, and various materials, services, and incidentals pertaining thereto shall conform with Contract Specifications Section 03 15 00, Concrete Accessories, Contract Specifications Section 03 20 00, Concrete Reinforcing, Contract Specifications Section 03 30 00, Cast-In-Place Concrete, Contract Specifications Section 03 05 15, Portland Cement Concrete, and Contract Specifications Section 03 35 00, Concrete Finishing.

C. Detectable warning surface shall comply with requirement with listed in Contract Specifications, Section 32 17 26, Tactile Surfacing.

1.03 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for concrete curbs, gutters and walks will be either by the lump sum method or by the unit price method as determined by the listing of the bid item for concrete curbs, gutters and walks indicated in the Bid Schedule of the Bid Form.

B. Lump sum: If the Bid Schedule indicates a lump sum for concrete curbs, gutters and walks, the lump-sum method of measurement and payment will be in accordance with Contract Specifications Section 01 20 00, Price and Payment Procedures.

C. Unit price: If the Bid Schedule indicates a unit price for concrete curbs, gutters and walks, the unit price method of measurement and payment will be as follows:

1. Measurement:

   a. Concrete curb, gutter, and combination curb-and-gutter will be measured for payment by the linear foot for each type installed.

   b. Sidewalks, including island paving, driveways, and ramps, will be measured for payment by the square yard for each type and thickness of concrete placed.

   c. Reinforcing steel, tie bars, and dowels, and expansion joints and contraction joints will not be measured separately for payment, and all costs in connection therewith will be considered included in the measurements of portland cement concrete curbs, gutters, and walks.

   d. Detectable warning surfaces will not be measured separately for payment. All costs in connection with the work will be considered to be included with the related item of work in the Bid Schedule of the Bid Form or incidental to the work.

2. Payment: Concrete curbs, gutters, and walks will be paid for at the indicated Contract unit prices for the computed quantities as determined by the measurement method specified in Article 1.03C., herein.

1.04 REFERENCES

A. American Concrete Institute (ACI):

1.	ACI 117	Specification for Tolerances for Concrete Construction Materials and Commentary
2.	ACI 301	Specifications for Structural Concrete
3.	ACI 318	Building Code Requirements for Reinforced Concrete and Commentary

B. American Society for Testing and Materials (ASTM):

1.	ASTM A53/A53M	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
2.	ASTM A615/ A615M	Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
3.	ASTM A663/ A663M	Standard Specification for Steel Bars, Carbon, Merchant Quality, Mechanical Properties

4. ASTM C260/ C260M — Standard Specification for Air-Entraining Admixtures for Concrete
5. ASTM C309 — Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
6. ASTM C881/ C881M — Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
7. ASTM C979/ C979M — Standard Specification for Pigments for Integrally Colored Concrete

C. State of California, Department of Transportation (Caltrans), Standard Specifications, latest edition:

1. Section 73 Concrete Curbs and Sidewalks

1.05 SUBMITTALS

A. General: Refer to Contract Specifications Section 01 33 00, Submittal Procedures, and Contract Specifications Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Product Data:

1. Submit the respective manufacturer's product data for manufactured products.
2. Submit product data and manufacturer's instructions for concrete color additives.

C. Shop Drawings:

1. Submit drawings that indicate the section profile of curb and gutter, and the locations of joints in concrete, including construction joints, expansion joints, isolation joints, and contraction joints.
2. Submit drawings of extruded curbs and gutters, if proposed, and any modification of the indicated section profile required by the extrusion process.
3. Submit drawings of reinforcing steel, tie bars, and connecting dowels. Comply with requirements specified in Contract Specifications Section 03 20 00, Concrete Reinforcing.

D. Samples:

1. Submit samples of colored concrete for differing locations for approval. Samples shall be 4 inches by 6 inches by 3/4 inch.
2. Approved samples shall be identified for each location.
3. Final colors shall match approved samples identified for each location.

1.06 QUALITY ASSURANCE

A. Tolerances:

1. Construct concrete surfaces within 1/4 inch of the indicated elevation, and deviating not more than 1/8 inch from a 10-foot straightedge placed anywhere on the surface.

2. Slab tolerances shall be “straightedge tolerance” as specified in ACI 117.

B. Finishes: Slab finishes shall be as specified herein in accordance with the requirements of ACI 301.

C. Site Mock-Ups: Provide site mock-up, in accordance with Contract Specifications Section 01 43 38, Field Samples and Mockups, at least 3 feet by 4 feet in size, of slab finishes for walks, for the Engineer’s review and approval. Site mock-ups require approval of the Engineer in writing before this work may proceed.

PART 2 – PRODUCTS

2.01 MATERIALS AND ACCESSORIES

A. Concrete Reinforcement: Refer to Contract Specifications Section 03 20 00, Concrete Reinforcing, for requirements.

B. Portland Cement Concrete: Refer to Contract Specifications Section 03 05 15, Portland Cement Concrete, for requirements. Provide Class of Concrete indicated on the Contract Drawings.

C. Benches and Chairs: ACI 318.

D. Tie Bars: ASTM A615/A615M, Grade 60, of type and size indicated.

E. Dowels: Plain round bars meeting requirements of ASTM A615/A615M, Grade 60, or ASTM A663/A663M, Grade 80, epoxy-coated bars, furnished with a cardboard sleeve.

F. Weep Holes: ASTM A53/A53M galvanized pipe of size indicated.

G. Expansion-Joint Filler and Joint Sealing Compound: Refer to Contract Specifications Section 03 15 00, Concrete Accessories, for requirements.

H. Surfacing Material for Nonslip Finish: Refer to Contract Specifications Section 03 35 00, Concrete Finishing, for requirements.

I. Concrete Curing Compound: ASTM C309, Type 1-D, Class A.

J. Detectable warning surfaces: Refer to Contract Specifications Section 32 17 26, Tactile Surfacing, for requirements.

K. Integral Color Concrete Pigment: ASTM C979/C979M.

PART 3 – EXECUTION

3.01 PREPARATION OF SUBGRADE

A. Excavate for and prepare the sub grade as specified in Contract Specifications Section 31 00 00, Earthwork, true to the indicated grade and cross section.

B. Test completed sub grade for correct grade and cross section by means of template supported on side forms.

C. Dampen sub grade and forms just before placing concrete.

3.02 TYPES OF CONSTRUCTION

A. Provide cast-in-place concrete construction, plain or reinforced as indicated. Curbs and gutters shall be formed accurately to indicated section profile with template screed. Cast-in-place concrete construction shall comply with requirements listed in Caltrans Standard Specifications Sections 73, as applicable.

B. Extruded curbs and gutter, placed by an extrusion machine, may be provided where site conditions are suitable and the extrusion process is appropriate for the purpose. Extruded curbs and gutters shall comply with requirements listed in Caltrans Standard Specifications Sections 73, as applicable.

3.03 JOINTS

A. Expansion Joints:

1. Construct 3/8-inch to 1/2-inch thick expansion joints in the following locations:

    a. In curb and combination curb and gutter at the locations of expansion joints in the concrete roadway.

    b. In curb or combination curb and gutter, at points where curved and tangent sections join.

    c. Between curb or combination curb and gutter, and any drain inlet, or similar structure occurring within the limits of the curb or combination curb and gutter.

    d. At corners in sidewalks, following the projections of the building lines from the corner of the building to the curb.

    e. Between sidewalks and any permanent structure.

    f. Between sidewalk and curb.

    g. Through sidewalks at intervals not greater than 60 feet.

h. In sidewalks, encircling fixtures more than 12 inches in diameter.

2. Construct expansion joints as specified in Contract Specifications Section 32 13 13, Concrete Paving, except that load transfer devices will not be required unless indicated. Shape preformed filler to cross section of curbs and combination curb and gutter.

B. Contraction Joints: In sidewalks, provide contraction joints as indicated in uniform intervals between 12-20 square feet, with the edges rounded to a 1/4-inch to 3/8-inch radius.

C. Tooling: Finish joints with an edging tool having 1/4-inch to 3/8-inch radius, leaving joints free of mortar and concrete. In preformed type joints, leave joint filler material exposed for full length of joint with clean and true edges.

D. Joint Sealing:

1. Seal to within 1/8 inch of pavement surface joints in curbs and gutters, including gutter surfaces of combination curb and gutter sections; all joints between curbs and vehicular pavement; all joints between gutters and vehicular pavement; and all other expansion joints. Do not seal other joints unless so indicated.

2. Do not seal joints until concrete curing is complete. Prior to installation of the joint sealing compound, clean the joints of dirt and other foreign material. Joints may be cleaned with compressed air jets provided that the air in such jets is free of oil or water. Do not fill joints when there is any free water in or adjacent to the joints. Joint walls and all surfaces to which the sealing material is to adhere shall be surface dry for at least three hours prior to sealing.

3. Apply with approved pressurized equipment. Perform sealing of joints to make them impervious to water and to prevent the sealing compound from spreading over the surface of the pavement.

3.04 FORM REMOVAL

A. Remove front curb forms not less than two nor more than six hours after placing concrete, but in no case while the concrete is still plastic enough to slump.

B. Remove other forms not less than twelve hours after finishing is completed.

3.05 FINISHING

A. Curb and Combination Curb and Gutter:

1. Trowel the face of curb smooth to a depth of not less than 2 inches below the flow line, or to the flow line of integral curb and gutter, and finish with a steel trowel, all immediately after removal of front curb forms.

2. Finish all curb edges with a radius of 1/2-inch.

3. Provide a final fine brush finish to both top and face of curb with brush strokes parallel to the line of the curb, so that both top and front face present the same uniform appearance.

4. Keep the curb face wet during above finishing operations.

5. Allow no coarse aggregate to show on the finished curb surface.

B. Sidewalk, Island Paving, and Ramps:

1. After the concrete has been placed, consolidated, struck off, leveled, grooved and edged as specified herein and in Contract Specifications Section 03 30 00, Cast-In-Place Concrete, and in Contract Specifications Section 03 35 00, Concrete Finishing, do not work the concrete further until ready for floating.

2. Provide “floated finish” or light “broom finish” as indicated in accordance with the requirements of ACI 301.

3. For pedestrian and wheelchair ramps, and all other surfaces where the Contract Drawings require a non-slip finish, provide a “nonslip finish” in combination with a “floated finish” or “broom finish” in accordance with the requirements of ACI 301.

4. Broom finish shall be applied perpendicular to the direction of traffic flow.

C. Joints and Edges: As soon as the condition of the work permits, perform joint work, edging, and marking. Finish all edges with a radius of 1/4 inch to 3/8 inch.

3.06 CURING AND PROTECTION

A. Comply with the applicable requirements of Contract Specifications Section 03 35 00, Concrete Finishing, for curing concrete with liquid membrane-forming curing compound. Do not permit traffic on new concrete pavement until the concrete has cured a minimum period of ten days.

B. Provide damp curing only, in accordance with Contract Specifications Section 03 35 00, Concrete Finishing, for concrete slab surfaces indicated to be treated with concrete hardener and dust proofer.

C. Provide color additive to match surrounding existing pavement, or as indicated on Contract Drawings. Cure and finish according to manufacturer’s recommendations.

3.07 DETECTABLE WARNING SURFACE

A. Provide detectable warning surface as indicated on Contract Drawings complying to requirements in Contract Specifications Section 32 17 26, Tactile Surfacing.

3.08 EXISTING CURBS AND SIDEWALKS

A. Repair of existing curb, sidewalk, curb ramp, driveway, or gutter, shall comply with Caltrans Standard Specifications Section 73-10.

3.09 FIELD QUALITY CONTROL

A. The Contractor shall perform inspections and tests as specified in Contract Specifications Section 03 05 15, Portland Cement Concrete. The Contractor shall provide such samples and services to facilitate testing as specified in Contract Specifications Section 03 05 15, Portland Cement Concrete.

END OF SECTION 32 16 21

SECTION 32 17 13

PARKING BUMPERS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Parking bumpers.

B. Adhesive.

C. Steel bars for installation.

1.02 MEASUREMENT AND PAYMENT

A. Measurement: Precast concrete parking bumpers will be measured for payment as an aggregate lump-sum unit, acceptably installed and completed.

B. Payment: Precast concrete parking bumpers will be paid for in aggregate at the Contract Lump-sum price, as indicated in the Bid Schedule of the Bid Form.

1.03 REFERENCES

A. State of California, Department of Transportation (Caltrans), Standard Specifications, latest edition:

1. Section 95 Epoxy

1.04 SUBMITTALS

A. General: Refer to Contract Specifications Section 01 33 00, Submittal Procedures, and Contract Specifications Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit Shop Drawings of bumpers, including plan layout and installation details, for approval.

C. Product Data: Submit manufacturers' product data of precast bumpers and epoxy adhesive for approval.

1.05 QUALITY ASSURANCE

A. Precast parking bumpers shall be manufactured for the intended purpose by a company or firm specializing in the manufacture of precast concrete parking appurtenances.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Parking Bumpers:

1. Provide precast concrete parking bumpers of half octagonal configuration and dimensions indicated on Contract Drawing. Unless indicated otherwise, provide bumpers 48 inches length.

2. Bumpers shall be manufactured of Class 4000 reinforced concrete, as specified in Contract Specifications Section 03 05 15, Portland Cement Concrete, to withstand constant use and rough service. Each bumper shall be reinforced with two No. 4 deformed steel reinforcing bars, minimum.

3. Bumper to be installed on at-grade asphalt pavement shall be manufactured with two holes to accommodate the installation rebar. Holes shall be positioned 6 inches in from each end and shall not exceed the dowel diameter by more than 1/4 inch.

4. Bumpers to be installed on concrete slabs of parking structures, shall be manufactured without holes.

B. Adhesive: Adhesive for anchoring bumpers or wheel stops to pavement shall be an epoxy adhesive manufactured for the purpose, similar and equal to the adhesives specified in Section 95 of the Caltrans Standard Specifications, Article 95-1.02.

C. Steel Bars for Installation: Epoxy-coated rebar, No. 5 size, conforming with applicable requirements of Contract Specifications Section 03 20 00, Concrete Reinforcing.

PART 3 – EXECUTION

3.01 INSTALLATION

A. For installation on asphalt pavements, precast concrete bumpers shall be anchored and secured in position on at-grade, as indicated, with two No. 5 epoxy-coated rebar and an appropriate epoxy adhesive as specified in Article 2.01.C and 2.01B herein.

B. For installation on concrete pavements, precast concrete bumpers shall be secured in position on at-grade concrete pavements, as indicated, with an appropriate epoxy adhesive as specified in Article 2.01.B herein.

END OF SECTION 32 17 13

SECTION 32 17 23

PAVEMENT MARKINGS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Traffic line paint and thermoplastic material for traffic striping and marking.

B. Application of traffic striping and control markings.

C. Removal of existing markings.

1.02 RELATED SECTIONS

A. Asphalt pavement is specified in Contract Specifications Section 32 12 16, Asphalt Paving.

B. Concrete pavement is specified in Contract Specifications Section 32 13 13, Concrete Paving.

C. Concrete curbs, gutters, and walks are specified in Contract Specifications Section 32 16 21, Concrete Curbs, Gutters, and Walks.

D. All other painting is specified under BART Facility Standards, Standard Specifications, Division 9, Finishes.

1.03 MEASUREMENT AND PAYMENT

A. Measurement: Pavement marking will be measured for payment by the lump sum method, acceptably performed and completed.

B. Payment: Pavement marking will be paid for at the indicated Contract lump sum price, as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. State of California, Department of Transportation (Caltrans), Standard Specifications, latest edition:

1. Section 84 Markings

B. State of California, Department of Transportation (Caltrans), California Manual on Uniform Traffic Control Devices (CA MUTCD), latest edition:

1. Part 3 Markings

C. California Air Resources Board (CARB):

1. Latest regulations governing permissible content of Volatile Organic Compounds (VOC) in paints

1.05 SUBMITTALS

A. General: Refer to Contract Specifications Section 01 33 00, Submittal Procedures, and Contract Specifications Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit drawings and diagrams, indicating stripe width of roadway divider stripes and parking stalls, configuration and dimensions of directional arrows, style and size of letters for “compact car” designation, configuration and dimensions of international handicapped symbol, and any other traffic control markings on pavement, such as “in” and “out” or “enter” and “exit” designations as indicated.

C. Certificate of Compliance: Submit evidence or affidavit that certifies that paint to be used complies with latest CARB/VOC regulations.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Paint and Thermoplastic Material: Provide paint and thermoplastic material conforming to the requirements of Section 84 of the Caltrans Standard Specifications, with colors as indicated on Standard Drawings Sheet CS20.

1. Provide glass beads where indicated on Standard Drawings Sheet CS20 conforming to the requirements of Section 84 of the Caltrans Standard Specifications.

B. Stall Numbers: Pre-cut thermoplastic numbers, 90 mil minimum thickness. Numbers shall be yellow, 12 inches high, Helvetica Light font.

PART 3 – EXECUTION

3.01 APPLICATION

A. Surface receiving application of paint or thermoplastic shall be prepared by methods specified in Section 84 of the Caltrans Standard Specifications.

B. Apply no paint or thermoplastic material until pavement has cured for at least three days or for the number of days as recommended by the manufacturer, whichever is longer. Ensure that pavement has cured sufficiently to carry application equipment without damage.

C. Provide traffic striping and control markings on pavement, parking stalls, and curbs in accordance with the layout, configurations, and dimensions indicated by Contract Drawings, approved Shop Drawings, and CA MUTCD.

D. Application equipment and procedures shall conform to the applicable requirements of the Caltrans Standard Specifications. Keep paint thoroughly mixed throughout application.

E. Traffic control markings and parking stalls shall be applied with the use of substantial cutout patterns and templates, or with striping equipment that applies straight, uniform width, sharp lines without fuzziness at the edges. Coverage shall be thorough and complete in accordance with the paint and thermoplastic manufacturer's instructions and recommendations and the Caltrans Standard Specifications.

1. Provide three coats for painted striping. Application rate per coat shall match the two coat system specified in the Section 84 of the Caltrans Standard Specifications. The third coat shall match the application rate of the second coat.

2. Apply thermoplastic material at a minimum thickness of 0.125 inch or at the manufacturer's recommended minimum thickness, whichever is greater.

F. Accessible parking stalls shall include the International Symbol for Accessibility.

G. At completion, the Contractor shall check the work thoroughly and shall touchup traffic control markings and parking stalls that are not distinct or thorough in coverage, or are not uniform in color.

3.02 TOLERANCES AND APPEARANCE

A. In addition to the tolerances and appearance requirements specified in the Caltrans Standard Specifications, edges shall be uniform with local variations not exceeding an eighth of an inch per foot and surfaces shall be smooth and uniform.

B. Letter sizes and patterns shall be as indicated on the Contract Drawings with variations of not more than plus or minus 15 percent in dimension.

3.03 REMOVAL OF EXISTING MARKINGS

A. Removal of existing markings shall conform to methods specified in Section 84 of the Caltrans Standard Specification.

END OF SECTION 32 17 23

SECTION 32 17 26

TACTILE SURFACING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Tile Materials

B. Tile Models

C. Fasteners and Accessories

D. Decals

1.02 RELATED SECTIONS

A. Requirements for dielectric insulation at platform edge are specified in Section 03 40 00, Precast Concrete and Section 07 13 19, Modified Bituminous Sheet Waterproofing.

1.03 MEASUREMENT AND PAYMENT

A. Separate measurement and payment will not be made for work required under this Section. All costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form or incidental to the Work.

1.04 REFERENCE STANDARDS

A. American Association of State Highway and Transportation Officials (AASHTO):

1. H20 Load Bearing Specifications

B. ASTM International (ASTM):

1. ASTM B117 Standard Practice for Operating Salt Spray (Fog) Apparatus
2. ASTM C39 Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
3. ASTM C97 Standard Test Methods for Absorption and Bulk Specific Gravity of Dimension Stone
4. ASTM C418 Standard Test Method for Abrasion Resistance of Concrete by Sandblasting
5. ASTM C496 Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens

6.	ASTM C501	Standard Test Method for Relative Resistance to Wear of Unglazed Ceramic Tile by Tabor Abraser
7.	ASTM C936	Standard Specification for Solid Concrete Interlocking Paving Units
8.	ASTM C947	Standard Test Method for Flexural Properties of Thin-Section Glass-Fiber-Reinforced Concrete (Using Simple Beam with Third-Point Loading)
9.	ASTM C1026	Standard Test Method for Measuring the Resistance of Ceramic and Glass to Tile Freeze-Thaw Cycling
10.	ASTM C1262	Standard Test Method for Evaluating the Freeze-Thaw Durability of Dry-Cast Segmental Retaining Wall Units and Related Concrete Units
11.	ASTM D543	Standard Practice for Evaluating the Resistance of Plastics to Chemical Reagents
12.	ASTM D570	Standard Test Method for Water Absorption of Plastics
13.	ASTM D638	Standard Test Method for Tensile Properties of Plastics
14.	ASTM D695	Standard Test Method for Compressive Properties of Rigid Plastic
15.	ASTM D696	Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics Between -30°C and 30°C with a Vitreous Silica Dilatometer
16.	ASTM D790	Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
17.	ASTM D1037	Standard Test Methods for Evaluating Properties of Wood-Base Fiber and Particle Board Materials
18.	ASTM D2486	Standard Test Methods for Scrub Resistance of Wall Paints
19.	ASTM D5420	Standard Test Method for Impact Resistance of Flat, Rigid Plastic Specimen by Means of a Striker Impacted by a Falling Weight (Gardner Impact)
20.	ASTM E84	Standard Test Method for Surface Burning Characteristics of Building Materials
21.	ASTM G151	Standard Practice for Exposing Nonmetallic Materials in Accelerated Test Devices that use Laboratory Light Sources
22.	ASTM G155	Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials

C. Federal Standards (FED-STD):

1. FED-STD-595C Colors Used in Government Procurement

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Product Data: Submit manufacturer's product data and installation instructions for the specified tactile warning and directional tiles including adhesives, sealants, and fasteners.

1. Include type and models of tiles to be installed and method of installation for each model.

2. Include dimensioned drawings of tile surface profiles.

3. Include maintenance and cleaning instructions for the tiles.

C. Shop Drawings: Submit the following:

1. Complete installation layout and details including:

a. Scaled and dimensioned plans of tile placement including tile sizes and joint locations.

b. Joint abutment and transition details that provide a smooth, continuous, and flush surface between all tiles including joint abutment between tiles and adjacent flooring, platform edge conditions, sidewalks, and other site conditions where tactile warning surfaces are to be installed.

2. Fabrication details.

3. Fastener types and locations.

4. Internal flange and grouting details, where applicable.

D. Samples: Submit full-size samples of the types of tactile warning and directional tiles to be installed in each color specified for the Engineer’s approval. Samples shall match the Engineer’s control samples.

E. Material Test Reports: Submit test reports from a qualified independent testing laboratory indicating that materials proposed for use are in compliance with requirements and meet the properties specified. Include test report of field testing.

F. Installer's Qualifications: Submit evidence of the tile manufacturer's approval of the qualifications and experience of the proposed installer.

1.06 EXTRA STOCK

A. Furnish new materials from same manufactured lot as materials installed and enclosed in protective packaging with appropriate identification. Furnish not less than two percent of the supplied materials for each type, color and pattern installed.

1.07 QUALITY ASSURANCE

A. Single Source Responsibility: Provide tiles and fasteners as supplied by a single manufacturer.

B. Installer's Qualifications: Engage an experienced installer certified in writing by tile manufacturer as qualified for installation and who has successfully completed tile installations similar in material, design, and scope to that indicated for the Contract.

C. Regulations: Provide tactile warning surfaces that comply with the detectable warnings on walking surfaces as follows:

1. Americans with Disabilities Act (ADA): Title 49 CFR Transportation, Part 37, Appendix A, ADA Accessibility Guidelines for Buildings and Facilities, Section 4.29.

2. California Code of Regulations Title 24, Part 2, California Building Code (CBC), Chapter 11B, Accessibility to Public Buildings, Public Accommodations, Commercial Buildings, and Public Housing.

D. Mock-ups: Provide mock-ups as described and as specified when required by the Contract Specifications Section 32 17 26, Tactile Surfacing.

1.08 DELIVERY, STORAGE AND HANDLING

A. Storage:

1. Store tiles and other materials in an area that is within 40-90 degrees Fahrenheit. Protect other materials from freezing. If manufacturer's storage requirements are more restrictive, comply with manufacturer's requirements.

2. Maintain storage facilities in a clean dry condition.

1.09 SITE CONDITIONS

A. Environmental Conditions and Protection: Maintain minimum temperature of 40 degrees Fahrenheit in spaces to receive tiles for at least 48 hours prior to installation, during installation, and for not less than 48 hours after installation. Store tiles in spaces where they will be installed for at least 48 hours before beginning installation. Subsequently, maintain minimum temperature of 40 degrees Fahrenheit in areas where work is completed. If manufacturer's requirements are more restrictive, comply with manufacturer's requirements. Comply with manufacturers' requirements for substrate temperatures.

1.10 GUARANTEE

A. In addition to the Guaranty of Work requirements in General Conditions Article GC4.9, tiles shall be guaranteed in writing for a period of five years from date of Acceptance. The guarantee shall include defective work, breakage, deformation, fading and chalking of finishes, and loosening of tiles, and shall cover the cost of labor and materials for repair or replacement.

PART 2 – PRODUCTS

2.01 TILE MATERIALS – PERFORMANCE CRITERIA

A. Sheet Molding Compound (SMC) Tile Material: Matte finish exterior grade glass and carbon reinforced polyester based SMC composite material with uniform color throughout thickness that meets or exceeds the following requirements:

1. Salt and Spray Performance (ASTM B117): No deterioration or other defects after 200 hours of exposure.

2. Abrasion Resistance (ASTM C501): 500 minimum.

3. Freeze/Thaw/Heat (ASTM C1026): No deterioration.

4. Chemical Stain Resistance (ASTM D543): No reaction to 1% hydrochloric acid, motor oil, calcium chloride, gum, soap solution, bleach, and antifreeze.

5. Water Absorption (ASTM D570): Not to exceed 0.10%.

6. Tensile Strength (ASTM D638): 11,600 psi minimum.

7. Compressive Strength (ASTM D695): 28,900 psi minimum.

8. Flexural Strength (ASTM D790): 29,300 psi minimum.

9. Flame Spread (ASTM E84): 25 maximum.

10. Accelerated Weathering (ASTM G151 or G155): $\Delta E<5.0$ at 2,000 hours minimum exposure.

11. Load Bearing (AASHTO H20): No damage at 16,000 pounds loading.

B. Vitrified Polymer Composite (VPC) Tile Material: Epoxy polymer composition that provides aluminum oxide particles in the truncated domes with an ultra-violet resistance matte finish coating that meets or exceeds the following requirements:

1. Salt and Spray Performance (ASTM B117): No deterioration or other defects after 300 hours of exposure.

2. Abrasion Resistance (ASTM C501): 500 minimum.

3. Freeze/Thaw/Heat (ASTM C1026): No deterioration.

4. Chemical Stain Resistance (ASTM D543): No reaction to 1% hydrochloric acid, motor oil, calcium chloride, gum, soap solution, bleach, and antifreeze.

5. Water Absorption (ASTM D570): Not to exceed 0.05%.

6. Tensile Strength (ASTM D638): 11,600 psi minimum.

7. Compressive Strength (ASTM D695): 19,000 psi minimum.

8. Coefficient of Thermal Expansion (ASTM D696): 2.78 x 10^{-6}/°F.

9. Flexural Strength (ASTM D790): 29,300 psi minimum.

10. Accelerated Aging Cycle Testing (ASTM D1037): No failure.

11. Abrasive Scrub Test (ASTM D2486): 0.06 minimum.

12. Impact Resistance (ASTM D5420): 550 in-lbf/in minimum.

13. Flame Spread (ASTM E84): 25 maximum.

14. Accelerated Weathering (G155): $\Delta E<3.0$ at 2,000 hours minimum exposure.

15. Load Bearing (AASHTO H20): No damage at 16,000 pounds loading.

C. High-Tech Concrete (HTC) Tile Material: Polymer mix concrete with blended aggregates formed with integrated domes using inorganic metal oxide pigments that meet or exceed the following requirements:

1. Compressive Strength (ASTM C39): 16,800 psi minimum.

2. Water Absorption (ASTM C97): No to exceed 0.25%.

3. Abrasion Resistance (ASTM C418): Not to exceed 0.008 cm^3/cm^2.

4. Tensile Strength (ASTM C496): 3,000 psi minimum.

5. Flexural Strength (ASTM C947): 3,000 psi minimum.

6. Freeze-Thaw Durability (ASTM C1262): 0.00%.

D. In addition to compliance with the specified test criteria and characteristics, detectable tactile warning surfacing products shall have been successfully field tested in service for a minimum of two years.

E. Detectable Warning Surfaces shall be in compliance with the requirements of CBC Article 11B-705. Requirements include truncated dome size and spacing, color and contrast, resiliency and sound-on-cane contact, requirements for specific locations, and detectable directional texture. Use in-line pattern truncated domes. Staggered pattern domes are not acceptable.

2.02 TILE MODELS

A. The following tile models are applicable to various conditions and locations as indicated in the Drawings or as described elsewhere in the Contract Documents:

1. Model 1: Cast-in-Place Tactile Detectable Warning Surface Tile

2. Model 2: Cast-in-Place Replaceable Tactile Detectable Warning Surface Tile

3. Model 3: Surface Applied Tactile Detectable Warning Surface Tile

4. Model 4: Directional Way-Finding Bar Tile

5. Model 5: Cast-in Place Radius Tactile Surface

6. Model 6: Surface Applied Radius Tactile Surface

7. Model 7: Modular Paver

B. Thickness and Lateral Dimensions: As indicated in the approved Shop Drawings.

1. Exception:

a. Thickness of HTC tile material: 11/16 inch, with a dimensional tolerance of plus or minus 0.0625 inches in accordance with ASTM C936.

C. Flange equipped models: Internal embedment flange of length and spacing as designated in the approved Shop Drawings. Provide 0.625 inch holes in flanges for grout distribution.

D. Color: Color shall be uniform and homogeneous throughout the tile and in conformance with FED-STD-595C as follows:

1. Yellow: Federal Color No. 33538.

2.03 FASTENERS AND GROUTING

A. Where applicable to type of tile material and installation described in the Contract Documents and the approved Shop Drawings, use 304 stainless steel fasteners in a fastening pattern as recommended by the tile manufacturer concealed with color-matched polyvinyl chloride plastic (VPC) caps. Locate fasteners as shown in the approved Shop Drawings.

B. For grout embedment installations:

1. Provide 304 stainless steel leveling bolts as recommended by the tile manufacturer.

2. Provide non-shrink grout over self-leveling mortar bed under tile to thickness as recommended by the tile manufacturer.

2.04 ACCESSORIES

A. Adhesives: As recommended by the tile manufacturer.

B. Perimeter sealant: As recommended by the tile manufacturer. Color: As specified by the Engineer.

2.05 DECALS

A. Printable media for wide format digital printers that applies directly to sealed and unsealed concrete, asphalt, brick tile, terrazzo, marble, vinyl flooring, brick, stucco, and unit masonry wall surfaces:

1. Aluminum foil material that naturally conforms to texture of surface and appears as a printed graphic.

2. Print directly to textured surface with no requirement for over lamination.

3. High friction surface that provides slip resistance and reflectivity.

4. Withstands heavy pedestrian traffic in hot, cold, and wet environments for not less than one year.

5. Installed with high performance pressure sensitive acrylic adhesive backing.

B. Physical Properties:

1. UV curing.

2. Contains no PVC or hazardous chemicals and can be aluminum recycled.

3. Thicknesses:

   a. Film: 16 mil.

   b. Adhesive: 2 mil.

   c. Liner: 5 mil.

4. Service Temperature Range: -40 degrees Fahrenheit to 176 degrees Fahrenheit.

5. Minimum Application Temperature: 32 degrees Fahrenheit minimum.

C. Design and location: As indicated in the Contract Drawings.

PART 3 – EXECUTION

3.01 PREPARATION

A. Substrate Condition: Ensure substrate is in suitable condition and in compliance with the tile manufacturer's recommendations.

B. Verify that concrete substrate has cured a minimum of 30 Days.

3.02 INSTALLATION

A. The application of adhesives, sealants, and mechanical fasteners and the installation of tiles shall be in accordance with the guidelines required by the respective tile manufacturers, the approved material submittals, and the approved Shop Drawings. In general, the following installation guidelines apply, unless specified otherwise by the tile manufacturer:

1. For Cast-in-Place: Pour and float concrete, set tile by tamping down into concrete until all air voids are removed, edge cut around the perimeter, and remove any protective material covering the tile.

2. For Surface Applied: Grind substrate, remove dust on tile and substrate, apply adhesive to back of tile, drill into concrete, install fasteners, clean tile surface, and apply perimeter sealant.

3. For Directional Tile: Grind substrate 3/16 inch deep, six inches wide, saw cut 3/4 inch deep grooves, remove dust on tile and substrate, apply adhesive to back of tile, drill into concrete, install fasteners, clean tile surface, and apply perimeter sealant.

4. For Modular Paver: Box out or saw cut concrete, lay a gravel or mortar bed, tamp paver onto substrate, place a 3/8 inch diameter rope at bottom of all joints, and apply joint sealant.

B. During preparation and installation, protect adjacent surfaces not designated to receive tiles.

C. Do not cut or otherwise alter domes at joints.

D. Mechanically clean surface to receive tile to remove dirt and other foreign material and roughen concrete surface in accordance with tile manufacturer's instructions. After mechanical cleaning has been completed, vacuum and power wash with clean water to remove all dirt and debris. Visually inspect surfaces for obtrusions or foreign matter. If obtrusions are present, grind away before proceeding.

E. Immediately prior to installing setting adhesive and tactile warning surfacing materials, inspect surfaces to ensure that they are structurally sound, clean, and dry, and free of voids, curing compounds, obtrusions, projections, loose material, dust, oil, grease, sealers, and other foreign materials that might prohibit the proper installation of setting adhesive and surfacing material.

F. Set tiles as detailed in the approved Shop Drawings.

G. Following the installation of tiles, apply perimeter sealant system to the joints between abutting tile and between tiles and other adjacent surfaces. Follow sealant manufacturer's recommendation for application and ensure that the joint is clean and free of debris. Cut away any excess adhesive to provide sufficient depth for sealant as required by the sealant manufacturer for the tile installation conditions.

3.03 PROTECTION AND CLEANING

A. Protect adjacent surfaces from damage from adhesives and sealants.

B. Protect tiles, sealant, and cement strip against damage during construction period to comply with manufacturers' specifications.

C. Protect against damage for rolling loads following installation by covering with plywood or hardwood sheets.

D. After areas have been fully tiled and sealant system applied, clean tile surfaces in accordance with the tile manufacturer's recommendations.

E. Clean tiles, using methods recommended by the tile manufacturer, not more than four days prior to date for Final Inspection.

F. Do not allow foot traffic on installed tiles until the perimeter sealant has cured sufficiently to avoid tracking.

3.04 PRINTING AND INSTALLATION OF DECALS

A. Print and install decals as recommended by the decal material manufacturer.

END OF SECTION 32 17 26

SECTION 32 17 28

TRAFFIC BARRIERS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Thrie-beam metal guardrail (Type A).

B. W-Beam metal guardrail (Type B).

C. Transition traffic barrier (Type C).

D. Concrete barriers with chain link fencing (Type D).

1.02 RELATED SECTIONS

A. Chain link fencing is specified in Section 32 31 13, Chain Link Fences and Gates.

B. Concrete formwork, concrete reinforcement, cast-in-place concrete, portland cement concrete, expansion joints, and curing and finishing of concrete are specified in applicable Sections Division 3, Concrete.

1.03 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for traffic barriers will be either by the lump sum method or by the unit price method as determined by the listing of the bid item for traffic barriers indicated in the Bid Schedule of the Bid Form.

B. Lump sum: If the Bid Schedule indicates a lump sum for traffic barriers, the lump sum method of measurement and payment will be in accordance with Section 01 20 00, Price and Payment Procedures, Article 1.03.

C. Unit Price: If the Bid Schedule indicates a unit price for traffic barriers, the unit price method of measurement and payment will be as follows:

1. Measurement:

a. Type A and Type B Traffic Barriers:

1) Traffic barriers will be measured for payment by the linear foot complete in place, measured from end to end of the metal beam rail, including off-sets and end sections.

2) Earthwork, concrete, posts, fasteners, and accessories for the traffic barriers will not be measured separately for payment. All costs in connection therewith will be considered as included in the linear foot measurement of traffic barriers.

b. Type C and D Traffic Barriers:

1) Traffic barriers will be measured for payment by the linear foot, constructed complete in place, measured along the centerline of the barrier.

2) Earthwork, reinforcing steel and concrete, dowels, expansion joint filler, chain link fence, and electrical grounding will not be measured separately for payment. All costs in connection therewith will be considered as included in the linear foot measurement of the traffic barriers.

2. Payment: Traffic barriers will be paid for at the indicated Contract unit prices for the computed quantities as determined by the measurement method specified in Article 1.03.C.1, herein.

1.04 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):

1. AASHTO M180 Standard Specification for Corrugated Sheet Steel Beams for Highway Guard rail

B. American Society for Testing and Materials (ASTM):

1. ASTM A153/ A153M Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

2. ASTM A307 Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 psi Tensile Strength

3. ASTM A563 Standard Specification for Carbon and Alloy Steel Nuts

4. ASTM A780/ A780M Standard Practice for Repair of Damaged Hot-Dip Galvanized Coatings

5. ASTM C33/ C33M Standard Specification for Concrete Aggregates

C. State of California, Department of Transportation (Caltrans) Standard Specifications, latest edition:

1. Section 57 Wood and Plastic Lumber Structures

2. Section 58 Sound Walls

3. Section 83 Railings and Barriers

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings:

1. Submit shop drawings of beam-type traffic barrier and all its components. Refer to AASHTO M180 for example requirements.

2. Submit shop drawings of concrete barrier and all its components. Include locations of expansion and contraction joints.

PART 2 – PRODUCTS

2.01 TYPE A AND B TRAFFIC BARRIERS

A. Posts: Grade and species of wood posts shall comply with the requirements in accordance with Caltrans Standard Specifications Section 57, of sizes indicated. Fabricate and pressure treat wood posts in accordance with Caltrans Standard Specifications Section 83-2.02B.

B. Rail Components: AASHTO M180, Type II, Class A. Provide W-Beam or Thrie-Beam as indicated. Include beam, transition, end, and buffer sections as required for complete and finished installations in accordance with Caltrans Standard Specifications Section 83-2.02B.

C. Bolts, Nuts, and Washers: Bolts, nuts, and other fittings shall comply with fabrication and galvanizing requirements in accordance with AASHTO M180 and Caltrans Standard Specifications Section 83-2.02B.

D. Concrete for Post Foundations: Regular concrete, weighing approximately 145 pounds per cubic foot, with a minimum compressive strength at 28 days of 3,000 psi. Maximum aggregate size: 1-inch (ASTM C33/C33M, Sizes Nos. 56 or 57). Maximum slump: 4 inches.

E. Fabrication:

1. Metalwork shall be fabricated in the shop and comply with Caltrans Standard Specifications Section 83-2.02B and AASHTO M180. Do not punch, cut, or weld in the field. Where holes are required to be made in the field, drill such holes.

2. Holes shall be slotted as necessary to provide for expansion and contraction and to facilitate construction of traffic barriers.

3. Galvanize components of bolted assemblies separately before assembly. When necessary to bend or straighten sections after galvanizing, perform such work without damage to the zinc coating.

4. Galvanized coatings that are damaged by fabrication or assembly, including punching and drilling of holes, shall be restored by field cold galvanizing or galvanizing repair in accordance with ASTM A780/A780M.

2.02 TYPE C AND D TRAFFIC BARRIERS

A. Formwork: Comply with applicable requirements of Section 03 11 00, Concrete Forming. Provide forms that will produce “smooth form finish” as specified in Section 03 35 00, Concrete Finishing.

B. Reinforcing Steel: Comply with applicable requirements of Section 03 20 00, Concrete Reinforcing. Dowels shall be smooth steel bars or rods as indicated.

C. Expansion Joint Filler: Comply with applicable requirements of Section 03 15 00, Concrete Accessories.

D. Cast-In-Place Concrete: Comply with applicable requirements of Section 03 30 00, Cast-In-Place Concrete.

E. Portland Cement Concrete: Comply with applicable requirements of Section 03 05 15, Portland Cement Concrete. Provide Class 3000 concrete, unless otherwise indicated.

F. Concrete Repair, Curing, and Finishing: Repair of surface defects, curing, and finishing of concrete shall conform with applicable requirements of Section 03 35 00, Concrete Finishing. Provide “smooth form finish.” Curing may be by curing compound.

G. Chain Link Fence: Comply with applicable requirements of Section 32 31 13, Chain Link Fences and Gates. Provide the type of fence indicated in the Contract Documents. Provide galvanized pipe sleeves and high-strength non-shrink grout for anchoring fence posts in concrete.

PART 3 – EXECUTION

3.01 INSTALLATION OF TYPE A AND B TRAFFIC BARRIERS

A. Posts:

1. Posts shall be installed at equal intervals in compliance with the construction requirements listed in Caltrans Standard Specifications 83-2.02C.

B. Rail Components:

1. Rail element connections and splices shall conform to the construction requirements listed in Caltrans Standard Specifications Section 83-2.02C.

C. Repair of Damaged Surfaces: Repair damaged galvanized surfaces in accordance with ASTM A780/A780M as herein before specified under Article 2.01E, “Fabrication,” herein.

3.02 CONSTRUCTION OF TYPE C AND TYPE D TRAFFIC BARRIERS

A. Provide excavation, sub grade preparation, backfill, and compaction as indicated in Contract Drawings and required to complete the Work in accordance with applicable requirements of Section 31 00 00, Earthwork.

B. Provide concrete traffic barriers constructed to configuration indicated in Contract Drawings.

C. Install chain link fence and barbed wire as indicated and in accordance with applicable requirements of Section 32 31 13, Chain Link Fences and Gates.

END OF SECTION 32 17 28

SECTION 32 31 13

CHAIN LINK FENCES AND GATES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Fencing and gate materials.

B. Concrete.

C. Fence and gate installation.

D. Electrical grounding.

1.02 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for chain link fences and gates will be either by the lump-sum method or by the unit-price method as determined by the listing of the bid item for chain link fences and gates indicated in the Bid Schedule of the Bid Form.

B. Lump sum: If the Bid Schedule indicates a lump sum for chain link fences and gates, the lump-sum method of measurement and payment will be in accordance with Specifications Section 01 20 00, Price and Payment Procedures, Article 1.02, entitled “Lump-Sum Measurement.”

C. Unit price: If the Bid Schedule indicates a unit price for chain link fences and gates, the unit-price method of measurement and payment will be as follows:

1. Measurement:

    a. Chain link fences will be measured for payment by the linear foot of each type and height complete in place, parallel to finished grade, from center to center of end posts.

    b. Gates, including gate hardware, will be measured for payment by the number of each type and size of gate installed complete in place.

    c. Earthwork, grout and concrete, barbed wire, fence closures to ground, and electrical grounding will not be measured separately for payment, and all costs therefore will be considered to be included in the measurements for chain link fences and gates.

2. Payment: Chain link fences and gates will be paid for at the indicated Contract unit prices for the computed quantities as determined by the measurement method specified in Article 1.02.C.1, entitled “Measurement,” herein.

1.03 FENCE CLASSIFICATIONS AND STANDARDS

A. Fence Code: Type of fence, dimensions, components, gates, and accessories are indicated on the Contract Drawings in accordance with the “Fence Code” on the Civil Standard Drawings and/or the Contract Drawings.

B. Fence Types: Chain link fencing shall be of the types indicated as follows unless otherwise specified in the Contract Documents:

1. Type CL — Zinc-coated steel fence fabric with galvanized steel posts, rails, caps, hardware, and fittings.

2. Type VCL — Polyvinyl chloride (PVC) coated steel fence fabric with vinyl-coated and factory-painted steel posts, rails, caps, hardware, and fittings in selected color.

3. Type RP — Type CL fence with slats or pickets, made of redwood or redwood-colored plastic, inserted vertically in the fence fabric.

C. Area Fence Standards:

1. Line Fencing: Materials, dimensions, and components of fencing are indicated on the Contract Drawings by means of a “Fence Code.” If no code is indicated, the fence shall be galvanized chain link fabric, posts, and accessories, as follows: fabric shall be 84 inches wide, secured at the top and bottom to tension wire, with three strands of barbed wire carried on extension arms above the fabric for an additional 12 inches, for a total height above ground of 96 inches.

2. High Voltage Facilities, Shops, and Yard Fencing: Materials, dimensions, and components of the fencing are indicated on the Contract Drawings. The fence shall be galvanized chain link fabric, posts, and accessories, as follows: fabric shall be 108 inches high, secured at the top and bottom to galvanized pipe rail, plus three strands of barbed wire carried on extension arms above the top rail, for a total height of 120 inches above ground.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM A53/A53M — Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

2. ASTM A121 — Standard Specification for Metallic-Coated Carbon Steel Barbed Wire

3. ASTM A123/A123M — Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

4. ASTM A153/A153M — Standard Specification for Zinc-Coating (Hot-Dip) on Iron and Steel Hardware

5. ASTM A392 — Standard Specification for Zinc-Coated Steel Chain Link Fence Fabric
6. ASTM A491 — Standard Specification for Aluminum-Coated Steel Chain Link Fence Fabric
7. ASTM A824 — Standard Specification for Metallic-Coated Steel Marcelled Tension Wire for Use with Chain Link Fence
8. ASTM B117 — Standard Practice for Operating Salt Spray (Fog) Apparatus
9. ASTM F567 — Standard Practice for Installation of Chain Link Fence
10. ASTM F626 — Standard Specification for Fence Fittings
11. ASTM F668 — Standard Specification for Polyvinyl Chloride (PVC), Polyoefin and other Polymer Coated Steel Chain Link Fence Fabric
12. ASTM F900 — Standard Specification for Industrial and Commercial Swing Gates
13. ASTM F934 — Standard Specification for Standard Colors for Polymer-Coated Chain Link Fence Material
14. ASTM F1083 — Standard Specification for Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures
15. ASTM A653/A653M — Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
16. ASTM A1011/A1011M — Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-alloy, High Strength Low-Alloy with Improved Formability, and Ultra-High Strength
17. ASTM F1184 — Standard Specification for Industrial and Commercial Horizontal Slide Gates
18. ASTM F3000/F3000M — Standard Specification for Polymer Privacy Insert Slats for Chain Link Fabric and Privacy Chain Link Fabric Manufactured Containing Pre-Installed Privacy Slats

B. Chain Link Fence Manufacturers Institute (CLFMI): CLFMI Publication, “Standards for Chain Link Fence Installation”

C. Federal Specifications:

1. RR-F-191/2E — Fencing, Wire and Post, Metal (Chain Link Fence Gates) (Detail Specification)

2. RR-F-191/4F Fencing, Wire and Post, Metal (Chain Link Fence Accessories)

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Product Data: Submit manufacturer's product data and specifications of the specified chain link fencing and gates.

C. Shop Drawings: Submit detailed Shop Drawings of the fences and gates layout, including installation details of the fencing, posts, gates, hardware, and accessories for review.

D. Samples: If PVC-coated fencing is indicated or specified, submit manufacturer's color chart of available colors and physical sample of selected color.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Requirements: Fencing shall include fabric covering, framework, barbed wire, razor coil when specified in the Contract Documents and supporting arms, concrete footings, gates, hardware, and all appurtenances and accessories as required for a complete installation. Heights of fences shall be as indicated in Contract Documents. When not indicated, line fencing, high voltage facility, shops and yard fencing shall conform with the Area Fence Standards specified herein in Article 1.03.

B. Fence Fabric:

1. Type CL Fence Fabric: Zinc-coated steel fabric conforming to ASTM A392 with Class 2 coating. Mesh size one-inch square fabricated No. 9 gauge wire unless otherwise specified in the Contract Documents.

    a. The Contractor may furnish aluminum-coated steel fence fabric conforming to ASTM A491, with one-inch square mesh size fabricated No. 9 gauge wire unless otherwise specified in the Contract Documents.

2. Type VCL Fence Fabric: Type CL fence fabric, PVC-coated in accordance with ASTM F668. Class 1, Class 2a, and Class 2b wire and fabric types are acceptable. Mesh size one-inch square fabricated No. 9 gauge wire unless otherwise specified in the Contract Documents. Color shall be as selected by the Engineer from manufacturer's standards, as specified in ASTM F934.

3. Type RP Fence Fabric: Type CL fence fabric, mesh size two-inch square, with California redwood or redwood-colored plastic slats inserted vertically through the mesh pattern. Redwood fence slats shall be nominal one inch by three eighths inch in size, and shall have stain applied to all surfaces in color as selected by the Engineer. Plastic slats shall have privacy factor of 75 percent, be ultra-violet (UV) resistant, have a minimum warranty of 15 years, be double-walled, self-locking, and made of high density polyethylene (HDPE) with minimum strength of 4000 pounds per square inch or other plastic if approved by the Engineer. Plastic slats shall meet ASTM F3000/F3000M designations. Slats shall be one piece, full height of fence fabric.

4. Selvages: Twisted and barbed at top and bottom selvages when barbed wire is used; knuckled at both selvages when barbed wire is not used; unless otherwise indicated.

C. Pipe Framework for Type CL and RP Fencing and Gates: Posts, braces and rails shall be standard weight galvanized steel pipe conforming to ASTM F1083. Provide sizes specified in Civil Standard Drawing CS01 Chain Link Fence or as indicated. Posts shall include galvanized bolted fittings to properly secure rails and braces to posts.

D. Under BART's direction, Alternate Pipe Framework for Type CL and RP Fencing as shown below may be used:

1. Pipe for Posts and Rails: Posts and rails shall be high-strength pipe manufactured from steel conforming to ASTM A1011/A1011M, cold-formed, high frequency or induction welded, and having a minimum yield strength of 50,000 pounds per square inch.

2. Posts and Rails and Braces: Sizes and weights shall be as specified in 2.01 C. Pipe Framework for Type CL and RP Fencing. Posts shall include galvanized bolted fittings to properly secure rails and braces to posts.

3. External Pipe Coating: External surface shall be triple coated with one ounce plus or minus 0.1 ounce of zinc per square foot, 30 plus or minus 15 micrograms of chromate per square inch, and a high-performance polymer. Pipe shall demonstrate the ability to resist 1,000 hours of exposure to salt spray with a maximum of five percent red rust when tested in accordance with ASTM B117.

4. Internal Pipe Coating: Internal surface of pipe shall be coated, after welding, with a zinc-rich based organic coating having a 91 percent zinc powder loading capable of withstanding 650 hours of exposure to salt fog with a maximum of five percent red rust when tested in accordance with ASTM B117. All coatings shall be applied inside and out after welding.

E. Pipe Framework for Type VCL Fencing: Post and rails shall be vinyl-clad steel with color-coated EMV (epoxy modified polyvinyl chloride) chemically bonded to heated standard weight ASTM F1083 galvanized steel pipe, as specified, by electrostatically applied powder coating process. Protective vinyl coating thickness shall be 10 to 14 mils, according to pipe diameter. Pipe vinyl coating shall have the following properties: specific gravity of 1.32 to 1.37; tensile strength of 2,000 pounds per square inch; minimum elongation of 180 percent; tear strength at 15 mils - 0.36 pounds per mil; hardness of coating of 87 to 92 Shore A Durometer. Color shall match fence fabric color. Sizes and weights shall be as specified for Type CL fence or alternate high-strength pipe framework.

F. Tension Wire: Tension wire for top and bottom edge support of fence fabric shall be No. 7 gauge marcelled wire, conforming to ASTM A824, Type II Zinc-Coated Class 5-2.0 oz/sf with minimum tensile strength of 80,000 pounds per square inch. For type VCL fencing, provide tension wire coated with PVC, matching fence fabric in color.

G. Post Caps and Fittings: Manufacturer's standard, pressed steel or malleable iron post caps, fittings, and accessories, meeting requirements of ASTM F626 and Federal Specification RR-F-191/4F, galvanized for Type CL and RP fencing, and PVC coating by the thermal-fusion-bond process, in color matching posts, for Type VCL fencing. Post caps shall be designed to fit securely over the posts to exclude water and to carry the top pipe rail and extension arms, where indicated. All other required fittings and hardware shall be provided to fasten to the pipe posts or concrete in the manner indicated.

H. Truss Rod Assembly: In compliance with ASTM F626, 3/8 inch diameter steel truss rod with a pressed steel tightener or self tightening turnbuckle, minimum zinc coating of 1.2 ounce per square foot, assembly capable of withstanding a tension of 2,000 pounds. Truss tightener must have a strap thickness of at least 1/4 inch.

I. Tension Bars: In compliance with ASTM F626. Galvanized steel one-piece length 2 inch less that the fabric height. Minimum zinc coating 1.2 ounce per square foot.

1. Bars for mesh size 2-inch square shall have a minimum cross section of 3/16 inch by 3/4 inch.

2. Bars for mesh size 1-inch square shall have a cross section of 3/16 inch by 3/8 inch.

J. Tension and Brace Bands: Galvanized pressed steel complying with ASTM F626 with a minimum steel thickness of 12 gauge (0.105 inch), minimum width of 3/4 inch, and minimum zinc coating of 1.20 ounce per square foot. Tension bands shall be spaced not greater than 12 inches on center.

K. Accessories: Provide miscellaneous materials and accessories, clips, tie wires (9 gauge), anchors, eye bolts, hog rings, and fasteners as required for a complete installation. All items shall be galvanized in accordance with ASTM A123/A123M or ASTM A153/A153M as applicable. Accessories for Type VCL fencing shall be vinyl-coated or painted to match color of fence fabric.

L. Barbed Wire Extension Arms: Pressed steel conforming to ASTM A653/A653M, hot-dip galvanized after fabrication, minimum zinc coating of 1.2 ounce per square foot, capable of supporting a vertical 250 lb load, complete with provision for anchorage to end, corner, and pull posts and for attaching three rows of barbed wire to each arm. Arms shall be 45-degree angle or vertical as indicated, for three strands of barbed wire. Arms shall be integral with post top weather cap. Intermediate arms shall have hole for passage of top tension wire. Arms shall be capable of withstanding 250 pounds downward pull at outermost end of arm without failure. Arms for Type VCL fencing shall be vinyl-coated or painted to match color of fence fabric.

M. Barbed Wire: Three-strand, zinc-coated, 12-1/2 gauge steel wire with 14 gauge, four-point steel barbs spaced 5 inches apart, conforming to ASTM A121. Zinc coating shall be Class 3, 0.80 ounce per square foot for 12-1/2 gauge wire and 0.65 ounce per square foot for 14-gauge wire.

N. Gates: Gates shall be swinging type or sliding type as indicated, furnished complete with all hardware and accessories as required for a complete installation.

1. Gate Frames: Frames shall be fabricated from zinc-coated steel pipe members (to match posts in Type CL and RP fencing). Sizes shall be specified in the Civil Standard Drawing CS01 Chain Link Fence or as indicated.

2. Fabrication: Conform to applicable requirements of ASTM F900, Federal Specification RR-F-191/2E, and the following:

    a. Assemble gate frames by welding or with fittings and rivets for rigid connections. Use same fabric as for fence. Install fabric with stretcher bars at vertical edges, and tie wires at top and bottom edges. Attach stretcher bars to gate frame at not more than 15 inches on center. Attach hardware with rivets or by other means that will provide security against removal or breakage.

    b. Provide additional horizontal and vertical members to ensure proper gate operation and for attachment of fabric, hardware, and accessories.

    c. Provide diagonal cross bracing consisting of minimum 3/8 inch diameter adjustable length truss rods on gates where necessary to provide frame rigidity without sag or twist.

    d. For Type VCL fencing, gate components shall be PVC-coated or painted in color matching fence fabric.

    e. For pre-engineered gates, stamped and signed calculations shall be provided by the manufacturer to verify gate design is adequate.

3. Gate Hardware:

    a. Swinging Gates:

        1) Provide gate hinges, latch, stop, and keeper for each gate leaf, conforming to applicable requirements of ASTM F900 and Federal Specification RR-F-191/2E. Provide latch with provision for locking gate with padlock. If locking provisions include chain, chain shall be hardened steel chain, bolt cutter resistant, tested to at least 9 tonnes of cutting force unless otherwise specified in Contract Drawings.

        2) Gate hinges shall be of adequate strength for the gate, and shall have large bearing surfaces for clamping or bolting in position. Hinge action shall be such that gates may be easily opened and closed by one person. Hinges shall provide for full 180 degree swing of gate leaf. Hinges shall be tack welded to post and gate after adjustment.

    b. Sliding Gates:

        1) Provide manufacturer's standard rubber-tired rollers and roller track for floor-supported sliding gates, conforming to applicable requirements of ASTM F1184. Include intermediate rollers or casters where required to prevent gate sag or deflection.

        2) Provide locking device and padlock eyes as part of latch for locking gate with padlock.

        3) Bottom of gate shall be guarded by a skirt around wheels and cantilever supports to maintain maximum allowable clearance under gate and around gate sides.

    c. Padlocks to be furnished by the District.

O. Pipe Sleeves: Pipe sleeves for fence post embedment in concrete curbs, barriers, and walls shall be fabricated from steel pipe conforming to ASTM A53/A53M and galvanized in accordance with ASTM A123/A123M, sized to receive and support fence posts.

2.02 CONCRETE

A. Provide concrete footings for fence posts under this Section. Concrete for posts shall have a minimum compressive strength at 28 days of 3,000 pounds per square inch, using one-inch maximum size aggregate and five sacks of cement minimum per cubic yard, with a maximum slump of four inches. Concrete and grout materials, placing, and curing shall conform to the applicable requirements of Section 03 30 00, Cast-In-Place Concrete, and Section 03 61 11, Non-Shrink Grout, respectively.

PART 3 – EXECUTION

3.01 PREPARATION

A. Installation of fencing shall not be started until final grading has been completed.

B. Locate fencing correctly as indicated.

C. Where posts are indicated or required to be embedded or set in concrete curbs, traffic barriers, or retaining walls, coordinate the installation of fencing closely with the installation of concrete as specified under Division 3 Concrete.

D. Furnish galvanized steel pipe sleeves for fence posts, as applicable, for installation in formwork at time required. Supervise installation of sleeves during formwork and placing of concrete to maintain exact dimensions according to template.

3.02 INSTALLATION

A. Install fencing and gates as indicated, in accordance with approved Shop Drawings, and applicable requirements of ASTM F567 and CLFMI Standards for Chain Link Fence Installation. Site fabricate as required to complete the fence installation.

B. Posts shall be plumb and rigid after installation. Gap between post and adjacent infrastructure shall be less than 2 inches. Rails shall be straight and tight. Chain link fabric shall be smooth and uniformly stretched tight and straight. Tension wires and barbed wires shall be pulled taut. Fabric shall be secured to the line post with tie wires spaced no greater than 12 inches on center and to rail spaced no greater than 18 inches on center. Turn ends of tie wire two-360 degree wraps around fabric. Tip to tie wire shall face away from public. Secure fabric to the tension wire with hog rings spaced no greater than 18 inches apart. Slats in Type RP fence shall be straight and plumb.

C. Drill holes for post footings in firm, undisturbed or compacted soil. Footing holes shall be not less than required dimensions of post footings per approved design. Excavate deeper as required for adequate support in soft and loose soils, and for posts with heavy lateral loads.

D. Where posts are indicated or required to be embedded or set in concrete curbs, traffic barriers, or retaining walls, grout or seal posts in sleeves as indicated.

E. Gates shall be installed plumb, level, and secure for full opening without interference. Install ground-set items in concrete for anchorage as recommended by the fence manufacturer. Adjust hardware for smooth operation and lubricate. Sliding gates shall operate smoothly and easily under minimum pressure.

F. Locate and install safety and restriction signs securely as indicated on the Contract Drawings.

G. Locate and install safety and restriction signs securely as indicated on the Contract Drawings.

H. Welds shall be protected by applying zinc rich paint in accordance with ASTM practice A780.

3.03 CONCRETE

A. Handling and placing of concrete shall conform to the applicable requirements of Section 03 30 00, Cast-In-Place Concrete.

B. Place concrete around posts in a continuous pour. Check each post for plumb and vertical and top alignment, and hold in position during placement and finishing operations.

C. Trowel finish tops of footings, and slope or dome to direct water away from posts. Set keepers, stops, sleeves, tracks, eye bolts, and other accessories into concrete as required. Wheel rolling area for sliding gates shall be steel-trowel smooth finish concrete.

3.04 ELECTRICAL GROUNDING

A. Ground fences and gates and perform other electrical grounding as indicated. Coordinate with the requirements of Section 26 05 26, Grounding and Bonding for Electrical Systems.

B. Install grounding material and access boxes in secure side of fences and gates.

C. Ground well boxes shall be in accordance with Section 34 21 60, Grounding and Bonding for Traction Power Facilities.

END OF SECTION 32 31 13

SECTION 32 31 17

HIGH SECURITY FENCES AND GATES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Fencing and gate materials.

B. Concrete.

C. Fence and gate installation.

D. Electrical grounding.

E. Privacy mesh.

1.02 RELATED SECTIONS

A. Section 01 33 00, Submittal Procedures

B. Section 01 33 23, Shop Drawings

C. Section 03 30 00, Cast In Place Concrete

D. Section 26 05 26, Grounding and Bonding for Electrical Systems

E. Section 31 00 00, Earthwork

F. Section 34 21 60, Grounding and Bonding for Traction Power Facilities

1.03 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for high security fences and gates will be by the unit-price method as determined by the listing of the bid item in the Bid Schedule of the Bid Form.

B. Measurement:

1. High security fences will be measured for payment by the linear foot of fence installed, complete in place, parallel to finished grade, from center to center of end posts.

2. High Security Gates, including gate hardware, will be measured for payment by the number of each type and size of gate installed, complete in place.

3. Privacy mesh will be measured for payment by the square feet installed, complete in place.

4. Earthwork, grout and concrete, barbed wire, expanded metal screen, fence closures to ground, fence anchorage to new or existing structures, fence and gate posts, fence and gate signs, gate locking mechanism, and electrical grounding will not be measured separately for payment, and all costs therefore will be considered to be included in the measurements for high security fences and gates.

C. Payment: High security fences and gates, and privacy mesh, will be paid for at the indicated Contract unit prices for the computed quantities as determined by the measurement method specified in Article 1.02.B, entitled “Measurement,” herein.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1.	ASTM A53/A53M	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
2.	ASTM A121	Standard Specification for Metallic-Coated Carbon Steel Barbed Wire
3.	ASTM A123/A123M	Standard Specification for Zinc (Hot-Dip Galvanized) coatings on Iron and Steel Products
4.	ASTM A153/A153M	Standard Specification for Zinc-Coating (Hot-Dip) on Iron and Steel Hardware
5.	ASTM A307	Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 psi Tensile Strength
6.	ASTM B117	Standard Practice for Operating Salt Spray (Fog) Apparatus
7.	ASTM F567	Standard Practice for Installation of Chain Link Fence
8.	ASTM F626	Standard Specification for Fence Fittings
9.	ASTM F900	Standard Specification for Industrial and Commercial Swing Gates
10.	ASTM F1083	Standard Specification for Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures
11.	ASTM A653/A653M	Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

12.	ASTM A1011/A1011M	Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High Strength Low-Alloy with Improved Formability, and Ultra-High Strength
13.	ASTM F1184	Standard Specification for Industrial and Commercial Horizontal Slide Gates
14.	ASTM F1043	Standard Specification for Strength and Protective Coatings on Steel Industrial Fence Framework
15.	ASTM F1267	Standard Specification for Metal, Expanded, Steel
16.	ASTM F1910	Standard Specification for Long Barbed Tape Obstacles
17.	ASTM F1911	Standard Specification for Installation of Barbed Tape
18.	ASTM F2548	Expanded Metal Fence Systems for Security Purposes
19.	ASTM F2780	Design and Construction of Expanded Metal Security Fences and Barriers

B. Chain Link Fence Manufacturers Institute (CLFMI): CLFMI Publication, “Standards for Chain Link Fence Installation”

C. Federal Specifications:

1.	RR-F-191/2E	Fencing, Wire and Post, Metal (Chain Link Fence Gates) (Detail Specification)
2.	RR-F-191/4F	Fencing, Wire and Post, Metal (Chain Link Fence Accessories)
3.	AA-55522	Commercial Item Description, Barbed Tape, Concertina

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Product Data: Submit manufacturer’s product data and specifications of the specified expanded metal fencing, gates, and privacy mesh.

C. Supplier and installation certification.

D. Shop Drawings: Submit detailed Shop Drawings of the fences, gates, and privacy mesh layout, including installation details of the fencing, posts, gates, privacy mesh, hardware, and accessories for review. Contractor shall verify all loads are considered and designed for and included with detailed Shop Drawings.

E. Samples: Submit manufacturer's floral pre-printed designer screen pattern charts and physical samples of selected privacy mesh.

1.06 QUALITY ASSURANCE

A. See Contract Specifications Section 01 43 00, Quality Assurance. Contractor shall ensure that manufacturer of the fencing system has a minimum of 5 years' experience in the design and fabrication of an expanded metal fence system.

B. Field measurements shall be taken prior to the submittal of final Shop Drawings and fabrication.

C. Each product type shall be the same and be made by the same manufacturer.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Requirements: Fencing shall include panel covering, framework, barbed wire, razor coil when specified in the Contract Documents and supporting arms, concrete footings, gates, hardware, and all appurtenances and accessories as required for a complete installation. Heights of fences shall be as indicated in Contract Documents. If required, privacy mesh will also be indicated in the Contract Documents.

B. Expanded Metal Panels:

1. Style – 1/2" R (Raised) - #13, design, materials, and installation must meet ASTM F2548 and ASTM F2780

2. Panel height: 3 feet - 7 feet, or any cumulative height as required

3. Panel width: 3 feet - 6 feet

4. Mesh diamond width: 0.500 inch x 1.20 inch long bond to bond

5. Mesh percent open area: 57 percent open area

6. Mesh percent open area with privacy mesh: 10 percent open area

7. Panel weight: 1.47 lbs per square feet

8. Galvanized Panel weight: 1.73 lbs per square feet

C. Pipe Framework: Posts and rails shall be standard weight galvanized steel pipe conforming to ASTM F1083. All posts, rails and braces shall have a yield strength of 30,000 psi. Gate posts and frames shall have a yield strength of 50,000 psi. Post or rails shall be installed in between line posts. Top, middle, and bottom post to be evenly spaced, with middle rail located midway between top and bottom rails. All posts shall include galvanized bolted fittings to properly secure rails and braces to posts. Sizes and weights shall be as follows unless otherwise specified in the Contract Documents:

1. Posts: Sizes shall be as shown on Standard Drawings.

2. Line Post Rails and Braces: Rails and Braces shall have an outside diameter of 1.900 inches weighing not less than 2.72 pounds per foot.

D. Under BART's direction, Alternate Pipe Framework for fencing as shown below may be used:

1. Pipe for Posts and Rails: Posts and rails shall be high-strength pipe manufactured from steel conforming to ASTM A1011/A1011M, cold-formed, high frequency or induction welded, and having a minimum yield strength of 50,000 psi.

2. Posts and Rails and Braces: Sizes and weights shall be as specified in 2.01 C. Pipe Framework for expanded metal fencing. Posts shall include galvanized bolted fittings to properly secure rails and braces to posts.

3. External Pipe Coating: External surface shall be triple coated with one ounce plus or minus 0.1 ounce of zinc per square foot, 30 plus or minus 15 micrograms of chromate per square inch, and a high-performance polymer. Pipe shall demonstrate the ability to resist 1,000 hours of exposure to salt spray with a maximum of five percent red rust when tested in accordance with ASTM B117.

4. Internal Pipe Coating: Internal surface of pipe shall be coated, after welding, with a zinc-rich based organic coating having a 91 percent zinc powder loading capable of withstanding 650 hours of exposure to salt fog with a maximum of five percent red rust when tested in accordance with ASTM B117. All coatings shall be applied inside and out after welding.

E. Line Rails: Rails for top edge, bottom edge, and mid support of fence panels shall be hot-dip galvanized after fabrication C-shape, U-shape, or similar shape. Rails shall be installed in between line posts. Top, middle, and bottom rails to be evenly spaced, with middle rail located midway between top and bottom rails.

F. Post Caps and Fittings: Manufacturer's standard, pressed steel or malleable iron post caps, fittings, and accessories, meeting requirements of ASTM F626 and Federal Specification RR-F-191/4F, galvanized for fencing. Post caps shall be designed to fit securely over the posts to exclude water and to carry the top pipe rail and extension arms, where indicated. All other required fittings and hardware shall be provided to fasten to the pipe posts or concrete in the manner indicated.

G. Accessories: Provide miscellaneous materials and accessories, clips, tie wires (nine gage), anchors, and fasteners as required for a complete installation. All items shall be galvanized in accordance with ASTM A123/A123M or ASTM A153/A153M as applicable.

H. Barbed Wire Extension Arms: Pressed steel conforming to ASTM A653/A653M, hot-dip galvanized after fabrication, minimum zinc coating of 1.2 oz/sf, capable of supporting a vertical 250 lb load, complete with provision for anchorage to end, corner, and pull posts and for attaching three rows of barbed wire to each arm. Arms shall be 45-degree angle or vertical as indicated, for three strands of barbed wire. Arms shall be integral with post top weather cap. Arms shall be capable of withstanding 300 pounds downward pull at outermost end of arm without failure.

I. Razor Wire: Barbed Tape, Concertina. Coil of single-strand-core wire fitted with barbed tape. Core wire shall be galvanized steel wire per ASTM A764, Finish 2, Class II, Type B with minimum tensile strength of 220,000 psi. Galvanized steel wire per ASTM A653, G60-G90 coating.

J. Barbed Wire: Three-strand, zinc-coated, 12-1/2 gage steel wire with 14 gage, four-point steel barbs spaced five inches apart, conforming to ASTM A121. Zinc coating shall be Class 3, 0.80 ounce per square foot for 12-1/2 gage wire and 0.65 ounce per square foot for 14-gage wire.

K. Line Post Footings: Sizes shall be as shown on Standard Drawings. Alternative footing designs may be acceptable so long as a set of calculations stamped by a licensed civil or structural engineer is provided to the District for review and approval.

L. Gates: Gates shall be swinging type furnished complete with all hardware and accessories as required for a complete installation.

1. Gate Frames: Frames shall be fabricated from zinc-coated steel pipe members to match posts in expanded metal fencing.

2. Fabrication: Conform to applicable requirements of ASTM F900, Federal Specification RR-F-191/2E, and the following:

   a. Assemble gate frames by welding or with fittings and rivets for rigid connections. Use same panels as for fence. Install panels with line rails, clamps (c-clamps, bar clamps, or similar clamps), nuts and bolts, and post clamps. Attach hardware with rivets or by other means that will provide security against removal or breakage.

   b. Provide additional horizontal and vertical members to ensure proper gate operation and for attachment of panels, hardware, and accessories.

   c. For pre-engineered gates, stamped and signed calculations shall be provided by the manufacturer to verify gate design is adequate.

3. Gate Hardware:

a. Swinging Gates: Provide gate hinges, latch, stop, and keeper for each gate leaf, conforming to applicable requirements of ASTM F900 and Federal Specification RR-F-191/2E. Provide latch with provision for locking gate with padlock. If locking provisions include chain, chain shall be hardened steel, bolt cutter resistant, tested to at least 9 tonnes cutting force. Padlocks to be furnished by the District. Additional bracing may be required due to added weight of expanded metal.

M. Gate Post Footings: Sizes shall be as shown on Standard Drawings. Alternative footing designs may be acceptable so long as a set of calculations stamped by a licensed California professional engineer is provided to the District for review and approval.

N. Pipe Sleeves: Pipe sleeves for fence post embedment in concrete curbs, barriers, and walls shall be fabricated from steel pipe conforming to ASTM A53/A53M and galvanized in accordance with ASTM A123/A123M, sized to receive and support fence posts.

O. Privacy Mesh: Privacy mesh shall be a floral pre-printed designer screen with multiple points of attachment. Mesh shall be manufactured using either Polyester, Polyethylene, High-Density Polyethylene, or similar material. Privacy blockage shall be 90 percent or greater.

1. Points of attachments (grommets) spacing shall be in accordance with approved Shop Drawings, grommets shall be galvanized or stainless steel.

2. Galvanized fasteners or hog rings, shall be provided to attach privacy mesh to high security fence.

3. Privacy mesh panels shall have folded welded edges for reinforcement.

2.02 CONCRETE

A. Provide concrete footings for fence posts under this Section. Concrete for posts shall have a minimum compressive strength at 28 days of 4,000 psi, using one-inch maximum size aggregate and five sacks of cement minimum per cubic yard, with a maximum slump of four inches. Concrete and grout materials, placing, and curing shall conform to the applicable requirements of Section 03 30 00, Cast-In-Place Concrete, and Section 03 61 11, Non-Shrink Grout, respectively.

PART 3 – EXECUTION

3.01 PREPARATION

A. Installation of fencing shall not be started until clearing and grubbing work and final grading has been completed.

B. Locate fencing correctly as indicated.

C. Where posts are indicated or required to be embedded or set in concrete curbs, traffic barriers, or retaining walls, coordinate the installation of fencing closely with the installation of concrete as specified under Division 3 Concrete.

D. Furnish galvanized steel pipe sleeves for fence posts, as applicable, for installation in formwork at time required. Supervise installation of sleeves during formwork and placing of concrete to maintain exact dimensions according to template.

3.02 INSTALLATION

A. Install fencing and gates as indicated, in accordance with approved Shop Drawings, and applicable requirements of ASTM F567, ASTM F2548, and ASTM F2780. Site-fabricate as required to complete the fence installation.

B. Posts shall be plumb and rigid after installation. Gap between post and any adjacent infrastructure shall be less than 2 inches. Rails shall be straight and tight. Barbed wires shall be pulled taut. Fence panels shall be installed straight and centered using fasteners where pre-punched holes are located.

1. Top rail shall be installed 8 inches below the top of the expanded metal mesh.

2. Bottom rail shall be installed 8 inches above the bottom of the expanded metal mesh.

C. Drill holes for post footings in firm, undisturbed or compacted soil. Footing holes shall be not less than required dimensions of post footings per approved design. Excavate deeper as required for adequate support in soft and loose soils, and for posts with heavy lateral loads. Remove all standing water prior to concrete pour.

D. Where posts are indicated or required to be embedded or set in concrete curbs, traffic barriers, or retaining walls, grout or seal posts in sleeves as indicated.

E. Gates shall be installed plumb, level, and secure for full opening without interference. Install ground-set items in concrete for anchorage as recommended by the fence manufacturer. Adjust hardware for smooth operation and lubricate.

F. Locate and install safety and restriction signs securely as indicated on the Contract Drawings.

G. Expanded metal overlapping:

1. Short Way of Diamond running horizontal – Overlapping shall occur at line post and midway between line post. Panels shall overlap 4-6 diamonds with diamonds oriented in the same direction. Panels to mesh with adjoining panel at diamonds.

2. Short Way of Diamond running vertical – Overlapping shall occur at bottom rail, top rail, and midway between top and bottom rails. Panels shall overlap 3-5 diamonds with diamonds oriented in the same direction. Panels to mesh with adjoining panel at diamonds.

H. Expanded metal panels shall have no more than one inch ground clearance between bottom of panel and grade or top of barrier.

3.03 CONCRETE

A. Handling and placing of concrete shall conform to the applicable requirements of Section 03 30 00, Cast-In-Place Concrete.

B. Place concrete around posts in a continuous pour. Check each post for plumb and vertical and top alignment. Hold in position during placement and finishing operations.

C. Trowel finish tops of footings, and slope or dome to direct water away from posts.

3.04 ELECTRICAL GROUNDING

A. Ground fences and gates and perform other electrical grounding as indicated. Coordinate with the requirements of Section 26 05 26, Grounding and Bonding for Electrical Systems.

B. Install grounding material and access boxes in secure side of fences and gates.

C. Ground well boxes shall be in accordance with Section 34 21 60, Grounding and Bonding for Traction Power Facilities.

END OF SECTION 32 31 17

SECTION 32 84 00

PLANTING IRRIGATION

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Irrigation materials and equipment.

B. Installation standards.

C. System location and layout.

D. Excavation and backfill.

E. Controller communications.

F. Water flow meters.

G. Plant establishment period.

1.02 RELATED SECTIONS

A. Section 01 33 00, Submittal Procedures.

B. Section 01 33 23, Shop Drawings, Product Data, and Samples.

C. Section 31 00 00, Earthwork.

D. Section 32 90 00, Planting.

E. Section 33 05 16, Utility Structures.

F. Section 33 05 28, Trenching and Backfilling for Utilities.

G. Section 33 11 00, Water Utility Distribution Piping.

1.03 MEASUREMENT AND PAYMENT

A. Measurement: Landscape irrigation system, including excavation, backfilling, and compaction, will be measured for payment by the lump sum method, acceptably performed and completed.

B. Payment: Landscape irrigation system, including excavation, backfilling, and compaction, will be paid for at the Contract lump sum price, as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM A53/A53M Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
2. ASTM D1557 Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2700 kN-m/m3))
3. ASTM D1784 Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds
4. ASTM D1785 Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
5. ASTM D2241 Standard Specification for Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR-Series)
6. ASTM D2287 Standard Specifications for Nonrigid Vinyl Chloride Polymer and Copolymer Molding and Extrusion Compounds
7. ASTM D2464 Standard Specification for Threaded Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
8. ASTM D2466 Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
9. ASTM D2564 Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems

B. California Code of Regulations, Title 24:

1. Part 3 California Electrical Code
2. Part 5 California Plumbing Code

C. State of California, Department of Transportation (Caltrans), Standard Specifications

1. Section 87 Electrical Systems

D. Underwriters Laboratories Inc. (UL):

1. UL 651 Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit detailed drawings and wiring diagrams of all mechanical and electrical equipment.

C. Product Data: Submit manufacturers' product data for irrigation equipment included in this specification.

D. Existing Irrigation Systems: Submit staged sequence of installation to the Engineer before site demolition commences.

E. Field irrigation survey.

F. Manufacturer's Installation Instructions: Submit installation instructions for control valves, flow meters, master control valves, and irrigation controllers.

1.06 CLOSEOUT SUBMITTALS

A. Refer to Section 01 79 39, Project Records Documents; and Section 01 78 23, Operation and Maintenance Data.

B. Irrigation Record Drawings shall be full size, and include water meter numbers. Irrigation valves shall not be color coded.

C. Controller charts.

D. Irrigation watering schedules.

E. Irrigation audit report.

F. Operation and Maintenance (O&M) Manual: Provide operation and maintenance instructions for the following items:

1. Electric remote control valves (including master control valves);
2. Satellite irrigation controllers;
3. Water flow meters;
4. Irrigation controller software and;
5. Maintenance schedule.

1.07 QUALITY ASSURANCE

A. Prior to the start of the irrigation installation, the Contractor shall arrange with the satellite irrigation controller manufacturer to provide pre-installation instructions and training on the proper installation and start-up of the irrigation control system.

B. Certified landscape irrigation auditor shall be certified to perform landscape irrigation audits by an accredited academic institution, a professional trade organization or other program including the Irrigation Association's Landscape Irrigation Auditor Certification program or U.S. Environmental Protection Agency "Watersense" labeled auditing program.

1.08 GUARANTY

A. Refer to the General Conditions Article GC4.9, Guaranty of Work, for Contract requirements.

B. Contractor's responsibility to repair or replace defective work shall be understood to include repair of affected adjacent work which is damaged by such defect. This includes damage to site improvements caused by settlement of improperly compacted trench backfill.

C. Provide the manufacturer's ten-year warranty. Warranty shall begin at the Substantial Completion.

D. The District reserves the right to make temporary repairs as required.

1.09 SITE CONDITIONS

A. Field Measurements: Verify actual grade elevations, service and utility locations, irrigation system components, by field measurements before proceeding with irrigation work.

B. Weather Limitations: Proceed with irrigation only when existing and forecasted weather conditions permit irrigation to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions and warranty requirements.

C. Do not perform any irrigation work in wet, muddy, or frozen conditions.

D. Protection of Work: Provide adequate protection for all irrigation components until Acceptance and start of the maintenance period. All damaged, vandalized, or disturbed irrigation equipment shall be replaced or repaired at the expense of the Contractor and to the satisfaction of the Engineer prior to completion and final Acceptance.

E. Field Irrigation Survey: Prior to the start of any construction the Contractor shall complete the following field irrigation survey:

1. Assess all wiring connections within the limit of work past the limit of work to the existing controller.

2. Assess laterals and mainlines downstream of the limit of work.

3. Run irrigation systems adjacent to the limit of work.

4. Record any part of the system that does not operate correctly.

F. Field irrigation survey shall include marked up Contract Documents and site photos. District Grounds Department staff shall be present at field survey site visit.

1.10 EXISTING IRRIGATION SYSTEM

A. The existing irrigation system and the extent of the work are indicated in the Contract Specifications and Drawings.

B. Location and quantities of the existing irrigation system and its indicated components are approximate. Irrigation drawings show which areas of the existing irrigation systems are to be modified and which areas of the existing landscaping are to be preserved.

C. Verify the condition of the existing irrigation system within the boundary of the work site before performing any work. Notify the Engineer, in writing, of any discrepancies found, including broken or inoperable main lines, branch lines, irrigation heads, and control valves.

D. Controllers, valves, valve box assembly components, sprinklers, and all other brass parts of the existing irrigation system to be removed or replaced shall remain the property of the District and shall be neatly stored in a locked area on District property, as directed by the Engineer.

E. The shut-off of parts of the existing irrigation system which are to remain in place, to be modified, or relocated, shall conform with the following requirements:

1. The Engineer shall be notified, in writing, 24 hours before shut-off and a written notice shall be submitted to the Engineer specifying the time when the system will be turned back on.

2. When shut-off of the irrigation system is longer than 72 hours, a full irrigation cycle of the system shall be performed before shut-off. Fully irrigate landscaped areas at least once every 48 hours.

3. Replace damaged plants and repair damaged areas that result from construction operations. Include damage resulting from lack of watering.

1.11 SEQUENCING AND SCHEDULING

A. Coordinate layout and installation of irrigation sleeves, conduits, and piping under paved areas and other features prior to their construction.

B. Coordinate installation of irrigation system with excavation of planting beds and backfilling of planting beds with topsoil. Refer to Section 32 90 00, Planting, for requirements. Typically, the irrigation system shall be installed after planting beds have been excavated and backfilled with topsoil.

C. The irrigation system shall be installed and tested prior to installation of plant material. Coordinate layout and installation of irrigation system with location and installation of plant material to assure that there will be complete and uniform irrigation coverage of planting as indicated.

D. Tree and shrub locations shall be staked in the field prior to installation of irrigation pipe and heads. Refer to the plant list on the Contract Drawings for plant setbacks and spacing requirements.

1.12 WRENCHES AND KEYS

A. Furnish and deliver to the Engineer two each of the following items upon completion of the work of this Section:

1. Wrench for each type of valve; and

2. Keys for valve box covers, controller panels, pedestal enclosure doors, and backflow preventer assembly enclosures.

B. Furnish and deliver to the Engineer four quick coupling keys with hose swivels and two keys for locking cover, all of same manufacturer as the valve.

C. The District will furnish padlocks and keys for enclosures that can be padlocked.

PART 2 – PRODUCTS

2.01 IRRIGATION MATERIALS AND EQUIPMENT

A. Requirements:

1. The landscape irrigation system shall consist of a completely automatic, electrically-controlled, drip, bubbler and spray-irrigation system. The system shall provide complete coverage with minimum maintenance. The irrigation system shall not overspray.

2. The landscape irrigation system shall be furnished and installed complete, including the following functions and features: connection to irrigation water stub-out; backflow preventer assemblies and enclosures; all pipe, fittings; valves; electric automatic controllers; electrical power to automatic controllers; the electric remote control valves; irrigation heads; valve boxes; electrical pullboxes and all appurtenances, incidentals, and accessories required for a complete and operable irrigation system. Exterior controllers shall be furnished and installed complete with enclosures and concrete base.

3. Irrigation materials and equipment shall be new, non-corroded, non-defective, that meet specified standards.

B. Piping: Above grade piping shall be galvanized steel. Below grade mains and laterals shall be rigid polyvinyl chloride (PVC).

1. Galvanized Steel Pipe: Galvanized steel pipe shall be Schedule 40, conforming to ASTM A53/A53M, Grade B, with 150 pound banded, galvanized malleable iron screwed fittings.

2. Plastic Pipe:

a. Plastic pipe shall be solvent welded polyvinyl chloride (PVC) 1120 or 1220 pressure-rated pipe. Supply lines (those lines from the meter or other irrigation point of connection to each valve, and to quick disconnects) shall be ASTM D1785, Class 12454-B, PVC1120 or PVC1220, Schedule 40.

b. Irrigation laterals (those lines from the valve to end of each run) shall be ASTM D2241, Standard Dimension Ratio (SDR) 13.5 (Class 315), for pipe 1/2 inch and smaller, and ASTM D1785, Class 12454-B (Schedule 40), for pipe 3/4 inch and larger.

c. Fittings shall be molded PVC, Schedule 40, conforming to ASTM D2466, Class 1433. Fittings shall be capable of withstanding maximum pressure rating of the pipe with which it is used. Provide Schedule 80 fittings conforming to ASTM D2464 where indicated or required.

d. Pipe thread sealant compound shall comply with requirements of ASTM D1784 or ASTM D2564, as applicable.

C. Conduit: Provide rigid non-metallic conduit conforming to UL Standard No. 651 for rigid non-metallic conduit, such as Schedule 40 PVC conduit, unless otherwise indicated.

D. Central Control Communication Equipment: Provide communication equipment master and auxiliary controllers.

1. Wireless Network (GPRS) Radio: Requires third party network General Packet Radio Services (GPRS) wireless service provider. Contact Controller representative to establish data service plan.

2. Spread Spectrum Radio communication between Master and Auxiliary controllers (wireless option): Provide a radio hub matching the controller manufacturer’s specifications.

3. Wireless Ethernet (WiFi) communication: Requires an existing 802.11 6/9 wireless network.

4. Local Radio: Provide an antenna, as recommended by the manufacturer, attached to a pole or nearby structure. Obtain Engineer's approval of location.

E. Electric Remote Control Valves and Master Control Valves: Rainbird models 100EFB-CP, 125EFB-CP, 150EFB-CP, 200EFB-CP straight pattern 300-BPE for three inch size, Designated Matching Products. Remote and master control valves shall meet the following requirements:

1. Valves shall have a contamination proof (CP) self-flushing nylon screen located at the valve inlet to filter out grit and prevent clogging of hydraulic control ports and assure reliable operation.

2. Valves shall be normally closed and be of the size indicated.

3. Valves shall be serviceable from the top without removing the valve body from the system.

4. Valves shall be equipped with a device that will regulate and adjust the flow of water, and with a manual shut-off.

5. Automatic closing time shall not be less than five seconds.

6. Valves shall be compatible with the electric automatic controllers.

7. Valve solenoid shall be designed for operation at 24-volts, AC, at 0.41 amps maximum in-rush current.

8. Valves shall be made of brass or bronze.

F. Unions: Unions shall be a minimum of 150-pound galvanized malleable iron with ground joints for above grade locations, and PVC schedule 80 threaded for below grade locations, and shall be provided on both sides of the wye strainer, control valves, and pressure reducing valve. Valves or strainer having integral union(s) are acceptable substitutes for union(s).

G. Master and Auxiliary Irrigation Controllers:

1. Master irrigation controllers shall provide local control of the irrigation system and transmit data to and receive remote control communication from District central computer.

   a. Subsequent controllers (if needed) shall be designated auxiliary controllers. Subsequent controllers shall have a communication link to the master controller.

2. Satellite Irrigation Controller. Calsense CS3000 series, Designated Matching Product. Controllers shall be furnished complete and have the following features:

   a. Independent control over each station start and stop time (dwell time), and number of cycles per day.

   b. 24-hour timer; 14-day minimum calendar period; dwell times adjustable in one-minute increments for 1 to 360 minutes and cycles of minimum four starts in 24 hours.

   c. 24-volt, 1.5-amp minimum output capacity with circuit breaker and with automatic reset and controller and valve surge protection.

   d. Number of stations as indicated.

   e. Six repeat watering programs (cycles, windows) per day capability.

   f. Two-minute dwell time for each station in event of power interruption.

   g. Simple “user friendly” keyboard programming with messages flashed on display screen to prompt entries by user.

   h. Retention of volatile program memory setting, time and date for up to 18 hours in event of power failure with rechargeable battery and trickle charger provided. Non-volatile, entry erasable programmable memory (EEPROM) is preferred.

   i. Shutdown and bypass of station in event of excess flow, sensed by flow meter, or excess current sensed by controller. Controller shall shut master control valve in the event excessive flow is sensed on three or more stations in succession. Default values shall be capable of being overridden by the Central Computer or manually at the controller.

   j. Suitable connection for District-owned receiver, prewired to allow complete automatic override of controller and remote operation of each valve by the District transmitter with 24-volt fuse protection and power supply connection for receiver.

   k. Computer Interface to a central computer, shall display statistics on each station operation. Statistics shall include: total flow, start and stop times for each cycle of operation of each station on a daily basis; valve failures, system failures or faults; power interruption occurrences and duration of outage; and total daily water consumption. In addition, computer interface linked through modem to Central Computer shall provide for adjustment, from remote computer, of each station start, and stop (dwell) times number of cycles. Interface shall be compatible with the District computer and related software.

   l. Manual actuation of each valve locally at the controller. This is in addition to the capability requirements for valve control by transceiver and remote control, statistical reporting to, and random access and reprogramming from the central computer.

   m. Keyboard with all control functions. Terminal strip for input/output connections easily accessible. Single 120-volt, single phase power connection and telephone line modem connection.

n. Scanning of station zone moisture condition and replenishment with multiple repeats during each daily watering program.

o. Simulation test board.

p. Default to last program preferred; default to preprogram required.

q. Five-Year Data Service Plan: Contractor to provide a five years data service plan, starting at the time of Acceptance.

3. Controller Enclosure and Pedestal:

a. Enclosure: Calsense Model CS3-SSE, District Designated Matching Product. Enclosure shall house irrigation controllers, complete with necessary inter-controller interface connections. For outdoor locations, enclosure shall be brushed stainless steel heavy-duty weatherproof and vandal-resistant with lockable, hinged, and gasketed door. Enclosure shall include antenna.

b. Enclosure shall feature a GFI receptacle and power disconnect switch.

c. Controller Protection:

1) Transient surge arrestor: DMP, Provide in the enclosure.

2) Transient protection board: DMP, Ground for lighting protection as indicated.

d. Pedestal: Calsense Model SSE-PED, Designated Matching Product. Pedestal shall be brushed stainless steel heavy-duty weatherproof, vandal-resistant with concrete base, furnished with, and exactly matching the cabinet.

e. Cabinet and pedestal shall be of welded construction with locks and shall provide security and protection of field wiring. Two keys for each cabinet door shall be furnished to the District. Locks shall be keyed alike.

H. Control, Common, and Spare Wires:

1. Low voltage control wire shall be Type UF, 600-V size as recommended by the manufacturer of the controller furnished for this project, but not smaller than No. 14 AWG. Common wire shall not be smaller than No. 12 AWG. Insulation shall be of a type approved by the California Electrical Code for underground direct burial, Class 2 wiring, 24-volt, 60 cycle, A.C. service.

2. Controller valve main wire insulation shall be black or red. Furnish different color control wire for each controller. Each common line shall be white with a color stripe to match the color of control wires it serves. Spare wire shall be a color different from control and common wires.

3. Control wire identification tags shall be two and a quarter inches by two and three fourths inches in size.

4. All splices made to electrical wires shall utilize connectors and sealing packs approved by the controller manufacturer. This includes an appropriately sized twist-on wire connector for making a UL-listed mechanical connection. Contractor shall follow the manufacturer's installation recommendation. Contractor shall confirm prior to use of sealing pack that the pack has not passed its expiration date. Splices shall be capable of satisfactory operations under continuous submersion in water.

I. Shut Off Valves: Valves for underground service shall be, at a minimum, 125-pound rating with non-rising stem. Valves shall be easily accessible, housed in a rectangular concrete valve box as specified in this Section.

1. Valves sized two and a half inches and smaller shall be 125 pound and have a screwed bronze body with solid bronze wedge gate and a stem with NPT threaded ends. Valve shall have a lockable operator with key. Valve wheels are unacceptable.

2. Valves sized three inches and larger shall be 250 pound and have a flanged cast iron body with bronze trim. Valve shall have a square head operator nut.

J. Valve Boxes and Control Wire Junction Boxes: Commercial precast concrete boxes shall be sized to adequately house the specific irrigation components indicated, including the electric remote control valve, master control valve, gate valves, flow meter, and pressure gage, furnished complete with a one-piece lockable cast-iron cover with lift handle.

1. Provide covers with vandal-resistant locking bolt.

2. Provide identification letters and numbers for controller and station number on rim of valve box stenciled in letters and numbers two inches high with epoxy-resin base paint of a contrasting color.

3. Cover for concrete boxes shall be marked "IRRIGATION" with embossed letters.

K. Valve Boxes for flush valves and air relief valves: Commercial plastic round boxes shall be sized to adequately house the specific valve indicated. Furnished complete with bolt down plastic lid. Boxes shall be green in color.

L. Backflow Assembly Enclosure:

1. A vandal-resistant solid aluminum cover shall enclose the backflow preventer, filter unit, and pressure-reducing valve. The filter shall be mounted upstream of the backflow preventer and provide nine-inches clearance between the filter drain valve and pad surface. The pressure reducing valve shall be provided downstream of the filter. Unions shall be provided on both sides of each component.

2. The cover shall be equipped with all stainless steel hardware and flush-mounted lockable hatch assembly designed for ease in handling. The cover shall be three inches clear of valve operating handles and appurtenances and shall be constructed of aluminum, with rigid, reinforced construction having a minimum corner angle, mid-section reinforcement and pre-punched viewing ports with rolled or relieved edges. The cover shall be bolted to a four-inch thick reinforced poured-in-place concrete pad that shall extend a minimum of three inches beyond the cover. The cover shall be anchored to the pad at each corner using minimum 1/4 inch by 2-1/2 inch anchor bolts of galvanized steel.

3. The padlock will be furnished by the District.

4. Bollards shall be provided at each corner of the protective enclosure.

M. Filters: The filter unit shall have a removable cylinder and integral resilient seat ball type drain valve. The free flow principle shall be intrinsic in the unit design, causing the water flowing along the cylinder to seep through the cylinder perforations, allowing particles to drop to the bottom for accumulation. The filter shall be suitable for 175 psig operating pressure and equipped with 155 mesh media. The unit shall have a factory-applied label affixed to the housing indicating media size and a flow arrow cast on the housing. The filter inlet and outlet for two-inch and smaller units shall be male pipe thread and for three-inch and larger units shall be 150 psi flanged. The unit shall have the following material of construction, capacities and filter area:

Size (inch)	Material of Construction Housing Cylinder	Maximum Flow (gpm)	Clean Pressure Drop @ Max. Flow (psi)	Filter Area (sq. in.)
3/4	Glass-filled Polyester Delrin or equal	8	1.4	11
1	Glass-filled Polyester Delrin or equal	30	1.5	20
1-1/2	Glass-filled Polyester Delrin or equal	80	2.0	40
2	Glass-filled Polyester Delrin or equal	110	1.9	132
3	Epoxy-coated stainless steel	180	1.5	240
4	Epoxy-coated stainless steel	350	2.0	365
6	Epoxy-coated stainless steel	700	2.0	730

N. Sleeves for Conduit and Water Lines: For pipe 3/4 of an inch through four inches in diameter, provide PVC Schedule 40 pipe, two pipe sizes larger than the water line and two pipe sizes larger than conduit. For pipe six inches in diameter and larger, provide corrugated metal pipe (galvanized) a minimum of one pipe size larger than the sleeved pipe.

O. Irrigation Heads: The sprinkler body, stem, nozzle and screen shall be constructed of heavy-duty, ultraviolet resistant plastic.

1. Sprinkler Heads and Bodies: Sprinklers shall be Rainbird RD1812-SAM-PRS w/Flow-Shield series, a District Designated Matching Product. Sprinkler shall have an ultra violet resistant plastic body and stem, 12-inch popup height, an integral check valve that holds up to 8 feet of head (3.50 psi), a heavy-duty stainless steel retraction spring, pressure regulation capability, flow shield build into the stem, a soft elastomer pressure-activated wiper seal, and a ratcheting system for easy alignment of the pattern. Riser nipples for all sprinkler heads shall be the same size as the riser opening in the sprinkler body.

2. Sprinkler nozzles: Sprinkler nozzles shall be of plastic construction, with matched precipitation rates for spray nozzles, flow and radius adjustment by use of a stainless-steel adjustment screw, filter screen and arc adjustment where specified.

3. Bubblers: Bubblers shall be a pressure compensating type, Rainbird 1400 or PCT (drip) series pressure compensating type, Designated Matching Products. Tree bubblers shall have a plastic inlet filter screen to protect the nozzle against clogging. Tree bubblers shall be of a permanently assembled design constructed of durable plastic with an integral rubber flow washer. Bubbler nozzles shall be attached to 18-inch long flexible connectors.

4. Flexible Connectors: Flexible connectors shall be extruded from integrally algae-resistant poly-vinyl chloride (PVC) resin conforming to ASTM D2287. The connectors shall be a minimum of 18 inches long and a maximum of 24 inches long.

P. Sub-surface Drip System: The drip system shall consist of a wye filter and pressure regulator at the remote control valve, dripline tubing, line flushing valves, and air/vacuum relief valves.

1. Wye Filter: Corrosion resistant plastic housing, one-inch FIPT/MIPT connections with removable stainless-steel screen and integral flush valve with hose threads. Screen shall be a minimum of 155 mesh.

2. Pressure Regulator: Constructed of thermoplastic with stainless steel compression spring and securing screws. Pre-set to maintain constant outlet pressure of 25 or 40 psi.

3. Dripline tubing and pressure compensating inline emitters: Extruded from linear low-density polyethylene. Tubing shall have a minimum nominal diameter of 1/2 inch with a minimum wall thickness of 0.050.

4. Line Flushing Valves: One half foot PVC ball valve solvent welded to a four foot coil of 1/2 inch IPS algae-resistant flexible PBVC pipe.

5. Air/Vacuum Relief Valves: Valve shall seal effectively from two to 10 psi.

Q. Backflow Preventer: Refer to Section 33 11 00, Water Utility Distribution Piping, for requirements.

R. Pressure Reducing Valve:

1. The main pressure-reducing valve shall be designed for 150-psig inlet pressure, and shall be furnished with an integral strainer. Pressure reducing valves two inches and smaller shall have a brass body with a reinforced, removable plastic diaphragm, stainless steel parts and a labeled outlet.

2. Pressure reducing valves three inches and larger shall be the self-contained diaphragm type with epoxy-coated cast iron bodies and 150 pound flanged inlets and outlets, replaceable seats with resilient discs, stainless steel or brass trim and integral pilots suitable for outdoor installation, 150 psig inlet pressure, and factory preset for 30 psig outlet.

S. Water Flow Meters: The water flow meter shall be Calsense Type FM series, a District Designated Matching Product. The water flow meter shall be a line-mounted, paddle-wheel impeller type of corrosion-resistant construction, designed to signal rate of flow to the Satellite Irrigation Controller.

T. Quick Coupling Valve: The quick coupling valve shall be Rainbird 33DLRC series, a District Designated Matching Product. The quick coupling valve shall be a two-piece type, 3/4 inch double track key lug with locking rubber cover. The valve body shall be constructed of red brass.

PART 3 – EXECUTION

3.01 INSTALLATION STANDARDS

A. The landscape irrigation system shall be installed in accordance with applicable requirements of the California Plumbing Code and California Electrical Code, and the requirements of the jurisdictional water authority.

B. Manufactured materials and equipment shall be installed in accordance with the respective manufacturer’s instructions for the location and conditions.

C. Electric automatic controller, electric remote control valves, electrical wiring, and the installation thereof shall conform with applicable provisions of Caltrans Standard Specifications Section 87, Electrical Systems, and the California Electrical Code.

3.02 SYSTEM LOCATION AND LAYOUT

A. It shall be the Contractor’s responsibility to lay out the irrigation system. Location of facilities indicated on Contract Drawings are approximate and diagrammatic and may require adjustment. Work shall be laid out as accurately as possible to conform with the Contract Drawings. Provide additional offsets, fittings, sleeves, and other devices that are required to complete the installation.

B. Irrigation system shall avoid conflicts with plant materials, lighting standards, signposts, architectural features, above and below ground utilities, and drainage system. Irrigation piping layout is schematic, showing location of pipes and fittings approximately. For example, where pipe is shown parallel or close to planting bed areas, it is intended that pipe be located inside the planting bed area.

C. Minimum flow through any spray valve shall be eight gallons per minute with 30 psi at the downstream side of the remote control valve and pressure-reduce valve.

D. Minimum flow through any drip circuit valve shall be three gallons a minute with 25 psi at the downstream side of the remote control valve and pressure valve.

E. Sprinkler spacing shall be in accordance with manufacturer's recommendations for overlapping coverage. All sprinkler heads shall provide head to head coverage with a minimum of one-foot overlap.

F. Laterals shall be installed not less than 12 inches from fences, curbs, sidewalks, and pavement, unless otherwise indicated.

G. Modifications: Provide modifications to the irrigation system to avoid blockage of sprinkler irrigation patterns, to prevent overspray and excessive runoff onto walkway and parking areas, and to provide full irrigation coverage to the planted areas. Such modifications also include trimming and adding heads as required to spray around trees, light poles, sign posts, other objects that obstruct spray pattern, and adjustments required as a result of trees being relocated or removed due to underground utility or drainage problems.

3.03 EXCAVATION AND BACKFILL

A. Provide excavating, bedding, and backfilling as specified in Section 33 05 28, Trenching and Backfilling for Utilities, as modified herein.

B. Trenches shall be only wide enough to provide sufficient working space on each side of the pipe for making joint and compacting bedding materials and backfill. The bottom of trench shall be graded and prepared to provide a firm and uniform bearing throughout the length of the pipe, sleeve, or conduit. Pipe, sleeve, or conduit shall be laid on three-inch thick layer of sand bedding material as specified in Section 33 05 28, Trenching and Backfilling for Utilities.

1. Trenches for lateral piping shall provide for a minimum of 12 inches of cover.

2. Trenches for mains and conduits shall provide for a minimum of 18 inches of cover.

3. Trenches under paving shall provide for a minimum of 24 inches of cover.

4. Trenches for subsurface drip lines shall be four inches deep, or as recommended by the subsurface drip line manufacturer.

C. After trenches have been excavated, pipe shall be installed, tested, and inspected, and the trench shall be backfilled without undue delay.

D. Before pipeline trenches are backfilled, the irrigation system shall be pressure tested and the location of irrigation heads modified as required to obtain complete and uniform coverage of each plant's root ball. Refer to field quality control requirements specified herein.

E. Graded sand backfill shall be provided for a minimum thickness of six inches above PVC pipe. Above sand backfill, backfill material in areas other than planting areas shall consist of material as specified in Section 33 05 28, Trenching and Backfilling for Utilities. Above the sand backfill, backfill in planting areas shall be topsoil from site excavations.

F. Compaction of backfill in landscaped areas shall be not less than that of surrounding ground as determined by ASTM D1557. Backfill materials shall be compacted in layers not exceeding eight inches in loose depth. Backfill material shall be placed and compacted in accordance with applicable requirements of Section 33 05 28, Trenching and Backfilling for Utilities, and Section 31 00 00, Earthwork.

3.04 INSTALLATION OF PIPE, EQUIPMENT, AND APPURTENANCES

A. Installation Requirements:

1. Piping installation shall be as indicated and in accordance with the respective manufacturer's instructions. No lines shall be installed directly over another line. Underground metallic pipes, valves, or fittings of dissimilar metals shall be connected through dielectric coupling or bushing and physically separated from other metal objects. Non-conducting spacers that will ensure physical separation of metallic pipe from foreign objects shall be provided as required.

2. Pipe, fittings, valves and irrigation heads shall be free from sand and dirt before installation. Foreign material shall be prevented from entering the irrigation system during installation. Immediately prior to assembly, all pipes, valves, and fittings shall be cleaned. Unattached ends of pipe, fittings, and valves shall be plugged or capped pending attachment of additional pipe or fittings. All lines shall be thoroughly flushed before attachment of irrigation heads.

3. Pipe shall be laid in the trench to the lines and grades indicated. During backfilling operations, pipe shall be supported so that no damage to pipe or joints occurs.

B. Rigid Plastic Pipe and Fittings:

1. Install as indicated and in conformance with the manufacturer's instructions. Rigid plastic pipe 1 1/2 inches in diameter and smaller shall be cut with a PVC cutter.

2. Bushings may be used only to reduce the pipe size between laterals and branches supplying water to irrigation heads.

3. Threaded fittings shall be used for all connections between PVC pipe and metal valves or pipe with threaded fittings using female adapter and Schedule 80 nipple. Use approved pipe joint compound on threaded PVC fittings. Assemble threaded PVC fittings finger-tight plus one to two 360-degree turns, but no more.

C. Valve Boxes and Extensions: Provide boxes at electric remote control valves, master control valve, pressure gages, flow meter, flush valve, and air/vacuum relief valve locations. Each valve box shall be installed on a foundation of brick and coarse aggregate as specified in Section 33 05 16, Utility Structures, and as indicated.

1. Valve boxes shall be installed in dirt or planted areas so that top of box is two inches above finish grade of soil. Set boxes square to adjacent paving edge or curb. Do not install boxes in paved areas.

2. Valve Boxes shall be installed on a continuous piece of one half inch mesh, 19-gage galvanized, woven wire cloth on a six inch bedding of gravel or crushed rock.

D. Control Wiring:

1. Install in conduit laid in trenches with main pipe lines. At valves, conduit shall terminate and both wires shall be brought into the valve box and an excess loop of 24 inches shall be provided before being spliced to solenoid pigtails. Splices will be permitted only in electrical pull boxes or valve boxes housing electric control valves. Wrap the 24-inch excess around a one-inch diameter pipe and coil neatly.

2. At least two feet of slack shall be left in each conductor at each splice.

3. Expansion loops of 18 inches shall be installed in continuous runs at 100 foot maximum spacing.

4. Attach identification tag to direct line wire at each valve, indicating identification number of valve (controller and station number). Tag shall be imprinted, durable polyurethane, and vandal resistant.

5. Three spare wires shall be installed from the controller and stubbed into each valve box served by the controller in series. The spare wires shall not be connected to any equipment at the time of installation.

6. Do not tie wires together when located in sleeves and conduits.

7. Provide additional concrete pull boxes on wire runs longer than 200 feet or conduit bends exceeding a cumulation of 270 degrees. Provide a 24-inch excess loop of wire in each pull box.

E. Sleeves:

1. Install sleeves for control wiring conduit and sleeves for piping that pass through foundations, footings, and foundation walls, and under walkways and paving. Wiring, conduit, pipe, or piping sleeves shall not be placed below footing, foundation, or wall. Where necessary, footing shall be lowered to six (6) inches minimum below such conduit or sleeve.

2. Wiring conduit and piping sleeves shall be of adequate size, a minimum of two pipe sizes larger than pipe lines and two sizes larger than required in California Electrical Code, Informative Annex C, Table C.2, to accommodate retrieval for repair of wiring or piping. Sleeve shall extend into planting areas a minimum of 12 inches beyond edges of footings, foundations walls, walkways, and paving.

3. Sleeves shall be installed straight and level.

4. Sleeves shall have removable PVC slip-on caps installed on both ends of sleeve to prevent entrance of soil or debris. Do not glue caps in place.

5. Sleeves under paving shall have a minimum of 24 inches of cover.

6. Provide spare pull wire in each electrical sleeve for future use. Label spare pull wire at each end with identification tag.

F. Pressure Gage: Maintain pressures within design tolerances. Check pressure of irrigation system upon installation of the system, immediately prior to Acceptance of the system, and regularly in between these times as necessary to maintain pressure within design tolerances.

G. Irrigation Controller:

1. Install as indicated and in accordance with manufacturer’s instructions. Install telephone lines, power lines, and grounding rods as indicated and required.

2. Connect remote control valves to controller in sequence according to plan. Attach identification tag to each control wire indicating station number of valve controlled.

3. Affix controller name (for example, “Controller A”) on inside of controller cabinet door with letters minimum one inch high.

4. Provide controller charts.

   a. Controller charts shall be an 11 inch by 17 inch copy of the “Record Drawings of the” irrigation after the irrigation is installed and accepted.

   b. Update the controller charts with any revisions to adjacent controllers.

   c. Controller charts shall show all valves operated by the controller, station number, valve size, and type of plants being irrigated. Each valve on the chart shall be marked with a different color to show its area of coverage.

d. Furnish three sets of controller chart for each controller supplied and a pdf copy. Two sets shall be supplied to District for maintenance staff, one set shall be sealed by plastic laminating and installed in the controller cabinet. Laminating sheets shall be at least 20 mil thick.

5. Install multiple pedestal controller cabinets side by side with 18 inches of separation. Door opening shall face adjacent paving. Cabinets shall be adjacent to and square with paving edge.

H. Controllers Communications:

1. For all communication types, coordinate a communication survey with controller manufacturer prior to installation of the controllers.

2. If antenna is required, connect antenna to controller using cable matching the controller manufacturer's specifications.

I. Water Flow Meters

1. The flow meter shall be installed after the water meter or backflow device and after the master control valve. The mainline pipe shall be sized during the installation to accommodate the fitting of the flow meter. Note the intended direction of the flow as indicated by an arrow on top of the flow meter. There shall be free, unrestricted pipe of the same size as the flow meter, with a length of at least ten times the flow meter size upstream or 30 inches, whichever is longer; and five times the flow meter size downstream or 20 inches, whichever is longer. This applies to the distance from any valve, fitting, meter, or backflow device.

2. Provide and adjust in accordance with the manufacturer's instructions, and with unions at either side to facilitate removal. Adjustment shall be made with the assistance of the manufacturer's representative at time of installation.

3. The flow meter shall be easily accessible, housed in a rectangular concrete valve box as specified in this Section.

4. The length of No. 14 AWG wire connecting the flow meter to the irrigation controller shall not exceed 2,000 feet.

3.05 CONTROLLER SCHEDULES AND PROGRAMMING

A. Contractor shall submit revisions to the irrigation schedules shown in the Contract Drawings based on built irrigation conditions.

1. Schedule shall include a landscape establishment period schedule and an established landscape schedule. The established landscape schedule shall meet the Maximum Applied Water Allowance (MAWA) as shown on the Contract Documents.

2. Any revisions to the Irrigation schedules shall be based on the requirements of the Department of Water Resources Water Efficient Landscape Ordinance (WELO) as well as the following:

    a. Irrigation schedules to show monthly irrigation by valve, precipitation rate by valve and include hydrozone groups. Schedule to show total monthly and yearly water use in gallons.

    b. Irrigation schedules shall allow for completion of site irrigation within an eight-hour nighttime watering window. Watering shall end before station opens no later than 6:30am.

B. Furnish three sets of established landscape schedule for each controller supplied as well as a pdf copy. Two sets shall be supplied to District grounds staff, one set shall be sealed by plastic laminating and installed in the controller cabinet. Laminating sheets shall be at least 20 mil thick.

C. The Contractor shall fully program the web-based controller dashboard with approved landscape establishment period schedule.

1. Program shall be a fully functioning, sustainable throughout the year program, weather and season reliant program with high flow, low flow, and mainline break alerts.

2. Flow rates obtained from automatic controller shall match Contract Documents. Contractor to submit Excel spreadsheet showing design flow rates and actual flow rates for review and approval prior to project Acceptance.

3.06 FIELD QUALITY CONTROL

A. Testing Requirements:

1. Each system shall be tested and approved before backfilling trenches. Electrical circuits shall be tested and operative prior to backfilling of trenches. Leaks in the irrigation system shall be repaired, defective materials replaced, and the test shall be performed again.

2. Prior to testing, sufficient backfill materials may be placed on pipes between fittings, couplings, and connections to ensure stability of the line. Fittings, couplings, and connections shall remain visible for the full period of the test. Before pressure testing, the system shall be flushed with control valves open. Pipe shall be plugged or capped where irrigation heads are to be installed, while testing the system.

3. The entire system shall be checked for uniform and complete coverage after installing and testing.

4. Mains, laterals, valves, fittings, and automatic electrical control valves shall be pressure tested. After assembly and installation, and after joints have cured for 24 hours, test main first, then capped laterals (before installation of heads). For mains, pump to 100 psi static pressure, then disconnect pump. Pressure gages shall be located at two points in the system and shall show no loss after a period of six hours. Laterals shall be tested at line pressure.

    a. Pipes, where pavement will be installed above, shall be retested, after subbase and base course material have been installed, in same manner as specified for mains, laterals, valves, and automatic electrical control valves.

B. Manufacturer's Field Services:

1. The Contractor shall provide a representative of the irrigation controller manufacturer who shall be responsible for site observations, training, and final inspection and approval of all connections.

C. Back Flow Preventers Test:

1. Testing of back flow preventers shall be conducted by a certified back flow preventer tester. The tester shall hold a valid certification as a back flow preventer tester from the county or other jurisdictional authority in which the device to be tested is located.

2. Test for back flow preventers shall be satisfactorily completed after installation of the back flow preventer assemblies and before operation of the irrigation system. Back flow preventers that fail the required tests shall be repaired or replaced and retested.

D. Irrigation Audit:

1. Contractor shall hire a certified landscape irrigation auditor to provide a third-party irrigation audit.

2. Irrigation audit shall not be conducted by the person who designed the landscape or installed the landscape.

3. An irrigation audit shall include, inspection, system tune-up, system test with distribution uniformity or emission uniformity, reporting overspray or runoff that causes overland flow, review of contractor provided irrigation schedule and review of controller programming. Irrigation audit shall summarize revisions required for the system to meet the requirements of the Model Water Efficient Landscape Ordinance.

4. The audit shall be conducted in accordance with the Irrigation Association's Landscape Irrigation Auditor Certification program or U.S. Environmental Protection Agency "Watersense" labeled auditing program.

E. Final Inspection:

1. Contractor shall submit irrigation audit report and make any corrections prior to the final inspection.

2. Prior to Acceptance of the Work, clean and adjust all systems. Operate systems under the observation of the Engineer. Irrigation heads shall be visually inspected for coverage. Remote control valves shall be properly balanced.

3. Upon completion of landscape planting and clean-up operations, the Contractor shall request a final inspection by the Engineer. The Contractor will not be permitted to begin the plant establishment period until after the Engineer has approved the landscape irrigation system installation in writing.

3.07 PLANT ESTABLISHMENT PERIOD

A. The plant establishment period, meeting, and reporting requirements shall be as specified in Section 32 90 00, Planting.

1. Three months prior to the end of the plant establishment period Contractor to program controller to use current reference evapotranspiration (ET) data and meet the Maximum Applied Water Allowance (MAWA). Contractor shall adjust irrigation system to sustain good plant health.

2. At the end of the plant establishment period controller shall not show any non-controller flow.

B. Irrigation Maintenance, Monitoring, and Repair.

1. The Contractor shall maintain electrical and irrigation systems throughout the plant establishment period. Maintain and adjust irrigation system and controller programming as needed to ensure healthy plant growth.

2. Assess the irrigation system while it is in operation at every site visit during the watering season. Contractor shall record all maintenance activities and observations in a monthly maintenance log book and note any changes or adjustments to the system on the Record Drawings.

3. Replace defective irrigation equipment immediately. If vandalism or theft occurs the Contractor shall alert the District immediately. If the Contractor does not alert District immediately, Contractor shall be responsible for all plant death due to the non-functioning irrigation equipment.

4. Perform the following weekly April through October and monthly November through March:

   a. Clean and adjust sprinkler and bubbler heads, drip emitters, and valves for proper coverage.

   b. Check and adjust irrigation system pressure.

   c. Assess and adjust irrigation controller programming to ensure healthy plant growth.

5. Perform the following systems check twice a year, at a minimum:

    a. Ensure all flush valve and cap locations and valve boxes are visible and can be opened.

    b. Inspect valves, filters, and pressure regulators for damage and leaks.

    c. Check wire splices.

    d. Clean valve boxes of dirt and debris.

    e. Inspect, clean, and flush filters and replace damaged or torn filters.

    f. Flush laterals.

    g. Make sure plants have adequate numbers of drip emitters for their size.

    h. Test backflow preventers.

    i. Other activities required to maintain irrigation system in working order.

3.08 TRAINING

A. Thirty Days prior to completion of the plant establishment period, the Contractor shall provide a course on the use, adjustment, programming, and maintenance of the automatic controllers, and irrigation heads. The instructions shall be given in one course of three, eight-hour days at a District Oakland office or on site as arranged for by the District.

B. Approximately ten District grounds staff will attend the course. The Contractor shall schedule the course through the Engineer at a time convenient to the District. The Contractor shall notify the Engineer of the proposed course dates at least six weeks prior to those scheduled dates.

END OF SECTION 32 84 00

SECTION 32 90 00

PLANTING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Plant material

B. Topsoil

C. Biotreatment soil

D. Compost

E. Fertilizers and soil amendments

F. Mulch

G. Backfill

H. Tree stakes and ties

I. Root barriers

J. Recycled cardboard (sheet mulch)

K. Decomposed granite

L. Soil test report and recommendations

M. Soil preparation

N. Finish grading

O. Drainage test and auger holes

P. Planting

Q. Pre-emergent Herbicides

R. Sodding (no-mow)

S. Preliminary inspection

T. Plant establishment period

U. Final inspection and acceptance

1.02 RELATED SECTIONS

A. Slope protection and hydro seeding are specified in Section 31 35 00, Slope Protection.

B. Landscape irrigation is specified in Section 32 84 00, Planting Irrigation.

C. Landscape removal is specified in Section 31 10 00, Clearing and Grubbing.

D. Rough grading is specified in Section 31 00 00, Earthwork.

1.03 MEASUREMENT AND PAYMENT

A. Measurement: Landscape planting work will be measured for payment by the lump-sum method, acceptably performed and completed.

B. Payment: Landscape planting work will be paid for at the Contract lump-sum price, as indicated in the Bid Schedule of the Bid Form.

1.04 DEFINITIONS

A. Backfill: The earth used to replace or the act of replacing earth in an excavation.

B. Balled and Burlapped Stock: Plants dug with firm, natural balls of earth in which they were grown; wrapped with burlap, tied, rigidly supported, and drum laced with twine with the root flare visible at the surface of the ball as recommended by ANSI Z60.1.

C. Balled and Potted Stock: Plants dug with firm, natural balls of earth in which they are grown and placed, unbroken, in a container.

D. Bare-root Stock: Plants with a well-branched, fibrous-root system developed by transplanting or root pruning, with soil or growing medium removed, and with not less than the minimum root spread according to ANSI Z60.1 for type and size of plant required.

E. CDFA: California Department of Food and Agriculture.

F. Compost: Product of controlled biological decomposition of organic materials, often including urban plant debris and food scraps. It is an organic matter resource that has the unique ability to improve the chemical, physical and biological characteristics of soils or growing media. It contains plant nutrients but is typically not characterized as a fertilizer. See Article 2.04 for requirements.

G. Container-Grown Stock: Healthy, vigorous, well-rooted plants grown in a container, with a well-established root system reaching sides of container and maintaining a firm ball when removed from container. Container shall be rigid enough to hold ball shape and protect root mass during shipping and be sized according to ANSI Z60.1 for type and size of plant required.

H. Finish/Finished Grade: Elevation of finished surface of planting soil.

I. Integrated Pest Management (IPM): A holistic approach to mitigating insects, plant diseases, weeds, and other pests. It involves the use of many strategies for managing, but not eliminating pests. IPM uses cultural, mechanical, physical, and biological control methods before using pesticides to control pests and diseases in the landscape. Chemical controls are applied only when monitoring indicates that preventative and non-chemical methods are not keeping pests below acceptable levels. When pesticides are required, the least toxic and the least persistent pesticide that will provide adequate pest control is applied.

J. Mulch: Any material spread evenly over the surface of the soil to enhance the growth of plants and the appearance of the landscape. See Article 2.06 for requirements.

K. Organic Materials Research Institute (OMRI): A national nonprofit organization that reviews products to determine their suitability for producing, processing and handling organic food and fiber under the USDA National Organic Program Rule.

L. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. Pesticides include insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. They also include substances or mixtures intended for use as a plant regulator, defoliant, or desiccant. Some sources classify herbicides separately from pesticides.

M. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. Pests include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.

N. Planting Area: Areas to be planted.

O. Planting Soil: Existing, on-site topsoil; imported topsoil; or biotreatment soil that has been modified with soil amendments and fertilizers to produce a soil mixture best for plant growth.

P. Plant, Plants, Plant Material: These terms refer to vegetation in general, including trees, shrubs, vines, ground covers, ornamental grasses, bulbs, corms, tubers, or herbaceous vegetation.

Q. Root Flare: Also called “trunk flare.” The area at the base of the plant’s stem or trunk where the stem or trunk broadens to form roots; the area of transition between the root system and the stem or trunk.

R. Stem Girdling Roots: Roots that encircle the stems (trunks) of trees below the soil surface.

S. Subgrade: The surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

T. US Composting Council STA (Seal of Testing Assurance) Program: Voluntary compost testing, labeling and information disclosure program requiring regular testing of compost using a standard suite of physical, chemical, and biological tests.

1.05 REFERENCE STANDARDS

A. American Association of Nurserymen:

1. American Standard for Nursery Stock

B. American National Standards Institute (ANSI):

1. ANSI A300 Pruning Standard
2. ANSI Z60.1 American Standard for Nursery Stock

C. Bay Area Stormwater Management Agencies Association (BASMAA):

1. BASMAA Regional Biotreatment Soil Specification

D. California Department of Food and Agriculture (CFDA):

1. Organic Input Materials Program

E. Organic Materials Review Institute (OMRI):

1. Generic Materials List

F. University of California, Davis:

1. Publication 8046 Planting Landscape Trees

G. US Composting Council:

1. Seal of Testing Assurance (STA) Certified Compost Program

H. US Department of Agriculture (USDA):

1. Handbook No. 60 Diagnosis and Improvement of Saline and Alkali Soils
2. National Organic Program

1.06 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures; and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Product Data:

1. Submit within 30 Days after Notice to Proceed and prior to start of Work:
    a. Proposed schedule and sequence of work plan for planting operations, with start dates and completion dates for planting trees, shrubs, and groundcover.

b. List of proposed equipment to be used for tree planting and plan for plant storage onsite.

2. Plant Information:

a. Plant Photographs: Include color photographs in digital format of each required species and size of plant material furnished in the Contract. Take photographs from an angle depicting true size and condition of the typical plant to be furnished. Include a scale rod or other measuring device in each photograph. For species where more than 30 plants are required, include a minimum of three photographs showing the average plant, the best quality plant, and the worst quality plant to be furnished. Identify each photograph with the full scientific name of the plant, plant size, and name of the growing nursery.

b. Plant Materials: Include quantities, sizes, quality, and sources for plant materials. Sort list by construction zone sequence if applicable.

c. Plant Substitutions (if applicable): Written request from Contractor to Engineer and written evidence from no less than three nurseries that the plant specified is not obtainable. Such evidence shall be submitted within 30 Days after the effective date of the Notice to Proceed.

3. Submit manufacturer's product data sheets for the following items:

a. Root barrier

b. Tree stakes and ties

c. Decomposed granite stabilizer

d. Weed barrier for decomposed granite

e. Mulch: Cut sheet verifying feedstock type, producer, and complete physical and chemical analysis of product

f. Compost:

1) Cut sheet verifying feedstock and source.

2) Submit compost technical data sheet including compost laboratory report, including test data summary page. If results are outside of acceptable parameters in Article 2.04 Contractor is responsible for retesting compost or finding an acceptable alternative. Laboratory report must be within one month of submittal date.

g. Cardboard: Cut sheet verifying weight and recycled content of cardboard.

h. Proposed products to be used in work. Indicate specific items and product numbers.

C. Soil Analysis Report and Recommendations: See Article 3.02.

D. Integrated Pest management (IPM) Strategy: Submit IPM strategy for use in the landscape planting work to control weeds, pests, and plant diseases.

E. Samples: Submit one sample to the job trailer for review by Engineer and mail one sample to Engineer as requested by Engineer. The following items shall be submitted in a 1-gallon volume of each in sealed, heavy duty, Ziplock-type plastic bag. Submittal shall be labeled with weight and source of each item. Each submittal shall represent a true sample of material to be provided at the Jobsite.

1. Imported topsoil, (if needed), including source of topsoil;
2. Compost;
3. Mulch;
4. Decomposed granite.

1.07 CLOSEOUT SUBMITTALS

A. Record Drawings: During the installation, carefully record in red line on a print of the planting plan, changes to be made to the planting system layout during installation. Record actual location of site elements installed, showing orientation and dimensions to fixed reference points. See Section 01 78 39, Project Record Documents.

1.08 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions of the following:

1. Plant material: ANSI Z60.1
2. Staking and guying procedures: Publication 8046
3. Pruning procedures: ANSI A300

B. Installer's Qualifications:

1. Contractor shall have a valid California C-27 Contractor's license authorized by the State of California. A California Contractor's license is required in the license classification in which the contractor will be working. Tree removal requires California license C-61/D-49.
2. Installer shall be a specialist in installing and planting landscape products, with documented five years' experience in performing landscape work of comparable size, scope, and quality. Provide list with a minimum of five installed projects with location, date completed, owner, contact person, and phone number. Projects shall have been completed successfully in the last ten years.
3. Professional Membership: Installer shall be a member in good standing of either the Professional Landcare Network or the American Nursery and Landscape Association.

4. Supervision: Provide the services of at least one qualified person who shall be present at all times during execution of the Work of this Section. That individual, who shall direct the Work, shall be thoroughly familiar with the types of materials being installed and the proper methods for their installation.

5. Arborist or tree worker shall be I.S.A. certified.

6. Personnel Certifications: Installer's personnel assigned to the Work shall have certification in one of the following categories from the Professional Landcare Network:

   a. Landscape Industry Certified Technician – Exterior.

   b. Landscape Industry Certified Interior.

   c. Landscape Industry Certified Horticultural Technician.

7. Pesticide Applicator: State licensed, commercial. Assign to the project at least one employee possessing a California State Chemical Applicator's License for the control of weeds, plant diseases, and other pests.

8. Contractor shall have an I.S. A. certified arborist or tree worker present on-site for the duration of tree pruning.

C. Engineer may choose to select all tree species at the nursery or place of growth prior to shipment.

D. Measurements:

1. Measure according to ANSI Z60.1. Do not prune to obtain required sizes.

2. Trees and Shrubs: Measure with branches and trunks or canes in their normal position. Take height measurements from or near the top of the root flare for field-grown stock and container-grown stock. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip to tip. Take caliper measurements 6 inches (150 mm) above the root flare for trees up to 4-inch (100-mm) caliper size, and 12 inches (300 mm) above the root flare for larger sizes.

3. Other Plants: Measure with stems, petioles, and foliage in their normal position.

E. Plant Material Observation: Engineer may observe plant material either at place of growth or at Jobsite before planting for compliance with requirements for genus, species, variety, cultivar, size, and quality. Engineer may observe trees and shrubs further for size and condition of balls and root systems, pests, disease symptoms, injuries, and latent defects and may reject unsatisfactory or defective material at any time during progress of Work. Remove rejected trees or shrubs immediately from Jobsite.

F. Do not install plants as indicated on Contract Drawings when obstructions, grade differences, or discrepancies between Contract Drawings and site conditions exist. Such discrepancies shall be brought to Engineer's attention for review and direction prior to initiating Work. In the event this notification is not performed, the Contractor shall assume responsibility for costs and required revisions to the work.

1.09 DELIVERY, STORAGE, AND HANDLING

A. General: Refer to Section 01 60 00, Product Requirements, for requirements.

B. Delivery:

1. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of compliance with state and Federal laws if applicable.

2. Bulk Materials:

   a. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.

   b. Provide erosion-control measures to prevent erosion or displacement of bulk materials: discharge of soil-bearing water runoff; and airborne dust reaching adjacent properties, water conveyance systems, or walkways.

3. Deliver bare-root stock plants within 24 hours of digging. Immediately after digging up bare-root stock, pack root system in wet straw, hay, or other suitable material to keep root system moist until planting. Transport in covered, temperature-controlled vehicles, and keep plants cool and protected from sun and wind at all times.

4. Deliver plant materials to Jobsite no earlier than three Days prior to planting. Deliver plants with legible identification labels, as follows:

   a. Label trees, bundles, and containers of like species.

   b. Labels shall state the correct plant name and size as specified in the plant list on the Contract Drawings and shall be legible for 60 Days after delivery to the planting site. Plant material that is not labeled will be rejected.

   c. State plant name and size indicated on the plant list.

5. If planting is delayed more than six hours after delivery, set plants and trees in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.

   a. Heel-in bare-root stock. Soak roots that are in less than moist condition in water for two hours. Reject plants with dry roots.

   b. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.

   c. Do not remove container-grown stock from containers before time of planting.

d. Water root systems of plants stored on-site deeply and thoroughly with a fine-mist spray. Water as often as necessary to maintain root systems in a moist, but not overly wet condition.

6. Protect plant material during delivery to prevent damage to root ball and desiccation of leaves.

7. Transport plants in enclosed trucks. If trees are too large for enclosed trucks and are transported in open trucks, trees shall be wrapped to prevent damage and windburn. Adequate protection shall be placed between trees so that trunks are not scarred in transport and branches are not broken. Tree trunks shall be wrapped with protective covering prior to handling and loading. Remove covering at the time of plant materials inspection at the Jobsite.

8. Notify Engineer at least ten Days in advance of delivery of plant materials and submit an itemized list of the plants in each delivery. Inspection certificates required by law shall accompany each shipment of plants, and the certificates shall be delivered to the Engineer.

C. Handling: Exercise care in handling, loading, unloading, and storing of plant materials. Plant materials damaged in any way shall be discarded and replaced with undamaged materials.

D. Storage:

1. Calcium carbonate (lime) shall not be stored with other landscape material. Herbicides and pesticides shall not be used or stored on District property.

1.10 SITE CONDITIONS

A. Field Measurements: Verify actual grade elevations, service and utility locations, irrigation system components, and dimensions of plantings and construction contiguous with new plantings by field measurements before proceeding with planting work.

B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer’s written instructions and warranty requirements.

C. Do not perform any planting or seeding in wet, muddy, or frozen conditions.

D. Protection of Work: Provide adequate protection for all planting and seeding until acceptance and start of the plant establishment period. Protect existing trees to remain, fencing, overhead, and underground utilities. All damaged, vandalized stained, or disturbed site materials or features and plants shall be replaced or repaired at the expense of the Contractor and to the satisfaction of the Engineer prior to completion and final acceptance.

1.11 GUARANTY

A. Refer to the General Conditions Article GC4.9, Guaranty of Work, for Contract requirements.

B. Guaranty that plants specified in Contract will take root and grow vigorously within one year after final acceptance of plantings, when such plants have received normal care and maintenance.

C. The guaranty shall include replacement of plants that die back or lose the form and size as originally specified, even though they may have taken root and are growing after the die-back.

D. Corrective work for the purposes of General Conditions Article GC4.9.2, shall include removal and replacement of guarantied plant materials that, for any reason, fail to meet the requirements of the guaranty. Replacements shall meet the same requirements as specified for the original materials. Replacements shall carry the same guaranty duration starting from time replacements are planted and accepted.

1.12 SUBSTITUTIONS

A. Plant substitutions will not be permitted unless approved by the Engineer. Request substitutions in writing to Engineer. Substitutions due to unavailability shall not be ordered before approval.

PART 2 – PRODUCTS

2.01 PLANT MATERIAL

A. Plant stock and materials are indicated in the planting list or schedule on the Contract Drawings. Provide trees and plants of the varieties, sizes, and quantities indicated.

B. Provide well-shaped, fully branched, healthy, vigorous stock, densely foliated when in leaf and free of disease, pests, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement. Provide nursery-grown stock only, that is free from insect pests and diseases. Plants shall comply with Federal and State laws requiring inspection for plant diseases and infestations.

C. Plants shall be true to species, varieties, and the sizes indicated, and shall be labeled in accordance with the recommended practice of the American Standard for Nursery Stock by American Association of Nurserymen.

D. Plants shall be healthy, shapely, and well-rooted. Roots shall show no evidence of having been root bound, restricted, or deformed. Plant material that has just been upgraded in container size will be rejected. Thin, weak, and leggy plants will be rejected.

E. Trees shall have straight trunks with the leader intact, undamaged, and uncut. Old abrasions and cuts shall be completely calloused over. Sizes shown on the Contract Drawings are before pruning. Trees shall not be pruned prior to delivery.

F. Trees shall be well tapered in the trunk so that when the nursery stake is removed, the tree supports itself upright without further staking. Trees shall have a main leader. The main branches shall be spaced vertically and alternately along the trunk. Branching shall not be concentrated in one location and there shall be no severe crossing of branches. Branches shall be smaller in diameter than the trunk. Branch attachments shall be free of embedded bark. Branching along the lower two-thirds of the trunk shall have at least one half of the foliage of the tree.

G. Trees with cut-off limbs more than 3/4 inch in diameter; or with stem girdling roots are unacceptable.

H. Plant material shall be grown under similar climatic conditions to those found at the Jobsite.

I. Ground cover and vines shall be rooted plants, grown in flats unless indicated otherwise on the Contract Drawings, or as approved by the Engineer.

2.02 TOPSOIL

A. Topsoil shall be fertile, friable surface soil free of grass; clods; plants; sods; clay lumps; roots; pockets of course sand; weeds; sticks; brush; stones 1 inch (25 mm) or larger in any dimension; and other materials harmful to plant growth. Topsoil shall not be infested with nematodes or other undesirable disease organisms such as insects and plant pathogens. Friable in these specifications refers to the structure and moisture content of topsoil. Friable topsoil shall be understood to mean topsoil that crumbles easily in the hand, does not stick to the hand, and does not form a ball when squeezed. Friable topsoil is not wet or muddy but is moist and damp. Topsoil shall be a friable condition at time of displacement including during transportation, placement, cultivation, and planting.

B. Imported topsoil shall be free from deleterious substances such as litter, refuse, toxic waste, stones larger one inch in size, coarse sand, heavy or stiff clay, brush sticks, grasses, roots, noxious weed seed, weeds, and other substances detrimental to plant, animal, and human health.

C. Total pore space content: On a volume/volume basis shall be at least 15 percent when moisture is present at field capacity. Topsoil shall have a field capacity of at least 15 percent by weight.

D. Organic matter content and USDA particle sizes shall be the following percentages by weight. The topsoil shall consist of sandy loam, with soil particles within the following percentages by weight:

1. Clay: 0 to 25

2. Silt: 25 to 50

3. Sand: 50 to 70

4. Decomposed organic matter: 5 to 10

E. Permeability: Hydraulic conductivity rate shall be not less than one inch per hour or more than 20 in. per hour when tested in accordance with USDA Handbook No. 60, Method 34b or other Engineer-approved methods.

F. Electrical conductivity: (ECe): Not exceed 3.0 millimhos per centimeter of the saturated extract at 25 centigrade.

G. Agricultural Suitability:

1. Acidity: pH range measured in the saturation extract (USDA Handbook No. 60, Method 21a) shall be 6.0 to 7.9.

2. Salinity: 0.5 to 2.0 dS/m as measured in the saturation extract (USDA Handbook No. 60 Method 3a). If calcium ions and sulfate ions both exceed 20 milliequivalents per liter in the saturation extract, the maximum shall be 4.0 dS/m.

3. Chloride: Maximum concentration of soluble chloride in the saturation extract (USDA Handbook No. 60, Method 3a) shall be 150 mg/l (parts per million).

4. Boron: Maximum concentration of soluble boron in the saturation extract (USDA Handbook No. 60, Method 3a) shall be 1 mg/l (parts per million).

5. Sodium Adsorption Ratio (SAR): Maximum SAR shall be six measured in accordance with USDA Handbook No. 60 Method 20b.

6. Calcium carbonate (limestone) shall not be present.

H. Heavy metals: Maximum permissible elemental concentration in soil shall not exceed the following:

Metal	Parts per million (mg/kg)[1]
Arsenic	3
Cadmium	2
Chromium	10
Cobalt	2
Lead	30
Mercury	1
Nickel	5
Selenium	3
Silver	0.5
Vanadium	3

I. Soil Fertility: Range of essential elemental concentration in soil shall be as follows:

[1] Ammonium bicarbonate/DTPA Extractable, dry weight basis.

Element	Low[2]	High[3]
Phosphorus	2	40
Potassium	40	220
Iron	2	35
Manganese	0.3	6
Zinc	0.6	8
Copper	0.1	5
Boron	0.2	1
Magnesium	50	150
Sodium	0	100
Sulfur	25	500
Molybdenum	0.1	30

J. Germination (bio-assay) test: Phytotoxic constituents, herbicides, hydrocarbons, and similar materials: Germination and growth of plants shall not be restricted more than 10 percent compared to standard controls. Standard controls shall be both monocots and dicots.

K. Total petroleum hydrocarbons shall not exceed 100 mg/kg dry soil measured in accordance with modified EPA Method No. 8015.

L. Total aromatic volatile organic hydrocarbons (e.g. benzene, toluene, zylene, and ethylbenzene) shall not exceed 2 mg/kg dry soil measured in accordance with EPA Method No. 8020.

M. Topsoil Source

1. Reuse surface soil stockpiled on the Jobsite if soil analysis report shows it can be used and amended to produce topsoil meeting requirements herein. Supplement with imported topsoil meeting requirements herein when quantities are insufficient.

2. Imported topsoil: From naturally well-drained sites where topsoil occurs at least 4 inches (100 mm) deep. Imported topsoil shall not come from bogs or marshes.

2.03 BIOTREATMENT SOIL

A. Biotreatment soil shall meet BASMAA Regional Biotreatment Soil Specification.

2.04 COMPOST

A. Compost shall:

1. Be mature, well decomposed, stable and weed free.

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[2] Ammonium bicarbonate/DTPA Extractable, parts per million (mg/kg), dry weight basis.
[3] Ammonium bicarbonate/DTPA Extractable, parts per million (mg/kg), dry weight basis. If soil is between 6 and 7, maximum permissible elemental concentration shall be reduced 50 percent. If soil pH is less than 6.0, maximum permissible elemental concentration shall be reduced 75 percent.

2. Be derived from agricultural, food scraps, or plant trimmings.
3. Contain no substances toxic to plants.
4. Be a dark brown to black color.
5. Smell of soil, forest, or mold.
6. Not smell of ammonia, rot, garbage, or sour.
7. Not resemble feedstock (original materials from which it was derived).
8. Be listed by CDFA as an Organic Input Material (OIM) or be approved by OMRI.
9. Be produced by a participant of the US Composting Council's STA Certified Compost Program.
10. Be generated from feedstock or materials sourced within 100-miles or produced at a facility within 100-miles of the Jobsite.

B. Compost shall meet the STA Compost Technical Data Sheet parameters as shown below. Laboratory report shall be dated within one month of submittal date.

Property	Unit of Measurement	Requirement
Moisture content	Percent wet weight basis	30 to 60
Organic matter Content	Percent dry weight basis	30 to 65
pH	Units	6.0 to 8.5 and mature
Soluble salts	dS/m (mmhos/cm)	Maximum 10
Particle size	Maximum aggregate size, inches	99 percent pass through 3/4 inch screen or smaller
Stability/Respiration Rate	mg CO_2-C/g OM per day	4 or below and stable
Percent Emergence	Average percent of control	80 percent or above and mature
Maturity	Average percent of control	80 percent or above
Fecal Coliform	Pass/Fail per US EPA Class A standard	Pass and safe
Salmonella	Pass/Fail per US EPA Class A standard	Pass and safe
Trace minerals	Pass/Fail per US EPA Class A standard	
Physical contaminants manmade inerts total content	Percent dry weight basis	Combined total: less than 0.5 percent
Physical contaminants man made inters sharps	Percent dry weight basis	None detected
Heavy Metals Content	Per EPA Class A 40CFR 503.13 tables 1 and 3	Pass
Sodium (Na)	Percent dry weight	Less than 0.5
Is your Compost Mature?		

Property	Unit of Measurement	Requirement
Biologically available Carbon		Stable
Ammonia N/Nitrate N ratio		Mature
Ammonium (N or NH4-N)	Mg/kg dry weight	Less than 450 and mature
Nitrate N	Ppm	Mature
C/N Ratio Carbon/Nitrogen Ratio	Carbon: Nitrogen	≤20:1 (and Nitrogen Neutral)

2.05 FERTILIZERS AND SOIL AMENDMENTS

A. Fertilizer and soil amendments shall be organic. Acceptable products are those allowed for use in crop production by at least one of the following:

1. OMRI Generic Materials List
2. CDFA Organic Input Materials Program
3. USDA National Organic Program

2.06 MULCH

A. Mulch shall be derived from chipped trees identified for removal onsite. If additional mulch is needed see below.

B. Mulch:

1. Shall be made from organic materials including tree trimmings, clean (unpainted and untreated) wood, or wood and plant trimmings.
2. Free of physical contamination with zero visible contamination at time of final walk-through. If contamination is present when mulch is delivered, Contractor shall reject load or remove contamination.
3. Shall not include forest industry products or byproducts such as redwood bark, peat moss, redwood “gorilla hair”, recycled tires, and any inorganic materials.
4. Generated from feedstock and materials sourced within 100-miles or produced at a facility within 100-miles of the Jobsite.

C. Acceptable mulch Suppliers shall be the following or equal:

1. Sonoma Compost (Vineyard mulch)
2. Greenwaste Recycle Yard (Treeincarnation premium mulch or mixed and aged mulch)

2.07 MULCH FOR BIOTREATMENT

A. Mulch for biotreatment shall meet mulch requirements of Article 2.06 A and B.

B. Mulch in biotreatment areas shall be float resistant “aged” mulch.

C. Acceptable mulch Suppliers shall be the following or equal:

1. Greenwaste Recycle Yard (mixed and aged mulch)
2. Zanker (Float resistant bio retention mulch)

D. Rock mulch as specified on Contract Drawings shall supersede this specification item.

2.08 BACKFILL

A. Backfill material for planting holes shall comply with topsoil specifications herein.

B. Amend backfill per soil analysis report.

2.09 TREE STAKES AND TIES

A. Tree Stakes: 3-inch diameter by 10 feet, straight, close-grained, lodge pole pine, untreated, pointed at one end.

B. Tree ties: Corded rubber tire strips – 1-inch-wide by 1/4 inch to 1/2 inch thick by length as required. Strips shall not contain steel within or have wire tie ends.

C. Tree stakes in tree wells with tree grate: Metal tree stake with integral tree ties that bolt to the tree grate. Number of stakes and securing of tree grates shall be per metal tree stake and tree grate manufacturer’s recommendations. A tree guard and tree ties may be used instead of metal tree stakes.

D. Provide palm bracing as indicated.

2.10 ROOT BARRIERS

A. Root Barrier: Black, molded, modular panels manufactured with 50 percent recycled polyethylene plastic with ultraviolet inhibitors, 85 mils (2.2 mm) thick, with vertical root deflecting ribs protruding 3/4 inch (19 mm) out from panel, and each panel 24 inches (610 mm) wide. Root barrier shall be UB 24 by DeepRoot or equal.

2.11 RECYCLED CARDBOARD (SHEET MULCH)

A. Recycled cardboard sheet mulch shall be 100 percent recycled B flute cardboard 70-pound weight supplied in minimum 50 feet by 36 inch rolls.

2.12 SODDING (NO MOW)

A. Refer to Contract Drawings.

2.13 DECOMPOSED GRANITE

A. Decomposed granite shall be crushed granite rock screenings, graded from 1/4 inch particles to dust, with uniform tan or buff color. Decomposed granite shall be mined and manufactured within 200 miles of the Jobsite. Decomposed granite shall conform with the following aggregate gradation:

Sieve Size	Percent Passing
No. 4	95-100
No. 30	30-50
No. 200	5-15

B. Binder/Stabilizer: Commercial-grade, polymer based, water resistant (once cured), non-toxic, low VOC (less than or equal to 5 g/l), and clear in color.

C. Weed barrier: Non-woven polyester (PET) landscape fabric that is high strength; non-biodegradable; and rot, mildew, and ultra-violet light resistant. Minimum weight per square yard shall be 2.0 ounces. Minimum thickness shall be 13 mils. Grab tensile strength shall be a minimum of 60.7 by 60.7 pounds. Weed barrier shall be Carthage Mills LX-SB Spunbond or equal.

2.14 SOURCE QUALITY CONTROL

A. Engineer will inspect the source of supply (landscape nursery) of the proposed plant materials prior to shipment to the Jobsite. Refer to the General Conditions, Article GC6.5, for requirements.

B. Engineer will inspect delivered plant materials. Plant materials that do not conform with specified requirements will be rejected, and shall be replaced with Engineer-approved plant materials.

PART 3 – EXECUTION

3.01 COORDINATION

A. Coordinate layout and installation of plant materials with installation of the irrigation system to ensure that there will be complete and full irrigation coverage of the planted areas.

B. Landscape work shall not begin until structures, utilities, paving, and other improvements, which require access to or through planting areas, have been installed and accepted by the Engineer. Planting work shall not begin until the landscape irrigation system is installed in place, tested, audited, and accepted by the Engineer.

3.02 SOIL ANALYSES REPORT AND RECOMMENDATIONS

A. Collect and perform soil analysis on one sample per 0.5 acre of each source of the proposed or existing topsoil. Obtain approval of sampling locations from the Engineer.

1. Take samples at the following depths:

   a. Shrubs, ground covers, and vine areas: 12 inches.

   b. Tree and palm areas: 1/2 depth of tree or palm pit.

B. An independent soil analytical laboratory shall perform the soil analyses. Laboratory shall follow analysis methods set forth in the USDA Handbook 60, the University of California Soil Fertility Test for Soils Analysis, and EPA. Soil analyses shall include:

1. Total pore space content.

2. Particle Size and Appraisal: Organic matter percent, USDA particle size.

3. Total pore space content on a volume/volume basis.

4. Permeability.

5. Electrical conductivity.

6. Agricultural Suitability: pH, salinity, chloride, boron, Sodium Absorption Ratio (SAR), calcium carbonate.

7. Heavy metals.

8. Soil Fertility: Phosphorus, potassium, iron, manganese, iron, copper, boron, magnesium, sodium, sulfur, molybdenum.

9. Germination (bio-assay) test.

10. Total petroleum hydrocarbons.

11. Total aromatic volatile organic hydrocarbons.

C. Recommendations for amending the soil with compost to bring the soil organic matter content to six percent and organic fertilizers and soil amendments to recommended levels for planting type.

1. The compost, amendment, and fertilizer rates and quantities listed in Article 3.07 shall be used for bid basis.

2. If compost quantity recommended by the soil analysis is less than rates listed in Article 3.07 Contractor shall still use bid rate. Other amendments and fertilizers shall be adjusted based on soil analysis results.

D. Submit report for Engineer's approval and obtain Engineer's determination of topsoil condition acceptability. If proposed topsoil is found unacceptable by Engineer, seek other sources of topsoil to import and conduct soil analyses on new sources until acceptable sources are found. Import topsoil from the accepted sources.

E. Do not add amendment to planting work until the Engineer has approved the soil analysis report.

3.03 EXAMINATION

A. Examine areas to receive plants, with installer present, for compliance with requirements and conditions affecting installation and performance of the Work.

1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, and acid has been deposited in soil within a planting area.

2. Verify that plants and vehicles loaded with plants can travel to planting locations with adequate overhead clearance.

3. Suspend planting operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.

4. Uniformly moisten excessively dry soil that is not workable, or that is dusty.

B. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Engineer and replace with new planting soil.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.04 EXCAVATION AND BACKFILL

A. Excavate and backfill areas to be landscaped as indicated.

B. Excavations for soil removal shall be within 6 inches of back of curb or edge of walk. Protect and maintain the integrity of compacted base rock and sub grade materials under paving and curbs, and protect other structures in the excavated areas. Review with the Engineer, the distance to remain away from other structures within the excavated areas. Do not undercut sides of excavation. Damage to base rock, sub grade, paving, curbs or structures shall be repaired or replaced. Remove and dispose of asphalt debris, concrete, base rock, and existing soil in landscaped areas from the Jobsite.

C. Excavation criteria:

1. In landscaped areas that were previously paved, or graveled, excavate to a minimum of 24 inches below the indicated finish grade. Excavate areas to receive trees to 36 inch depth within a 6 foot radius of each tree.

2. In planting areas not previously paved, for bid purposes assume this soil can be saved in place, tested and amended per requirements of Article 3.02 Soil Analysis Report and recommendations and Article 3.07 Soil Preparation. For topsoil removed and reused elsewhere on-site do not assume it can be reused until testing has been performed.

D. Backfill excavated tree and shrub planting areas with approved topsoil. Prior to installing topsoil, scarify the bottom of the excavation to a 6-inch depth. Do not scarify or undercut sides of excavations. Protect base rock and sub grade compaction under adjacent paving and curbs. Provide topsoil backfill in 6-inch lifts. Incorporate the first 6-inch lift of topsoil into the existing soil at the bottom of the excavation.

E. Refer to Section 31 00 00, Earthwork, for requirements for disposal of surplus material from planting bed excavations.

3.05 ROUGH GRADING

A. Prior to planting, grade areas to be landscaped. Fill as needed or remove surplus dirt and float areas to a smooth uniform grade. Slope planting areas to drain. Roll, scarify, rake, and level as necessary to obtain true, even planting surfaces. Rough grading shall be inspected and approved by the Engineer before compost or soil conditioners are added.

B. Planting areas shall be thoroughly wetted down. Allow soil to dry so as to be workable, after which thoroughly cultivate to a depth of 6 inches using a rotary hoe.

C. Compact soil in planting beds to 75 percent relative compaction to prevent future settling.

3.06 ROOT-BARRIER INSTALLATION

A. Root barriers shall be installed where trees are planted within 48 inch of paving or other hardscape elements such as walls, curbs, and walkways. Root barriers shall be installed in a linear fashion along hardscape edge and shall not wrap around tree root ball. Install per manufacturer’s instructions.

3.07 SOIL PREPARATION

A. Compost, soil amendments, and fertilizers shall be spread evenly over entire planting area according to soil analysis results and recommendations. For bidding purposes only, rates shall be as follows:

1. Compost: 6 cubic yards per 1,000 square feet (do not decrease based on soils report results).

2. 8 pounds ammonium sulfate (21-0-0) organic per 1,000 square feet.

3. 20 pounds soil sulfur per 1,000 square feet.

B. Incorporate into the top six inches of soil by repeated rotary-hoe cultivation.

C. Planting backfill shall comprise of:

1. Three parts pulverized site soil;

2. One part compost;

3. And the following amendments per cubic yard of backfill mix:

   a. 1/4 pound ammonium sulfate (21-0-0)

   b. 1 pound soil sulfur

3.08 FINISH GRADING

A. When weeding and soil preparation have been completed and soil has been thoroughly water settled, landscaped areas shall be finish graded for placement of plant materials. Grading shall be performed when the soil is at optimum moisture content for working.

B. Remove stones larger than 1 inch in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them from District property.

C. Finished grades shall be in accordance with the grading details for mounding in landscaped areas. Landscaped areas shall slope uniformly for positive drainage.

D. Grades not otherwise indicated shall be uniform levels or slopes between points where elevations are given, or between points established by walks, paving, curbs or catch basins. Finish grades shall be smooth, even, and on a uniform plane with no abrupt change of surface and no erosion scars.

E. Grading shall provide natural runoff of water without low spots or pockets. Flow line grades shall be accurately set and shall be not less than two percent gradient unless otherwise indicated or approved by the Engineer.

F. Finish grade of earth in landscaped areas shall be two inches below the top of adjacent pavement, curbs and headers, with a gradual tapering away from these structures to a uniform depth of 3-1/2 inches below the top of adjacent pavement, curbs, or headers, unless indicated otherwise on the Contract Drawings. Finish grade of earth shall be 3-1/2 inches below the top of pull and utility boxes, utility structures, and drain inlets. Pull and utility boxes shall be adjusted by raising or lowering to conform to grading requirements in landscaped areas.

G. Tops and toes of slopes shall be rounded to produce a gradual and natural-appearing transition between relatively level areas and slopes.

H. Protect planting areas against compaction by construction equipment.

I. Before planting, obtain Engineer's acceptance of finish grading. Restore planting areas if eroded or otherwise disturbed after finish grading.

3.09 DRAINAGE TEST AND AUGER HOLES

A. Requirements: After tree pits are dug and before planting operations, tree pits shall be water tested for drainage. One location per 80 square feet of tree pit shall be tested. Test tree pits in any area where a test tree pit does not drain within 24 hours, such as in hardpan areas, rocky ground, construction backfill, compacted areas, flat ground, and low spots, in order to ensure that pits in those areas will drain properly.

B. Tests: Fill tree pits with water. Check holes after 24 hours to determine if water has drained out. If the water has not drained out, bring this to the attention of the Engineer for remedial course of action. Adjustment of pit size, adjustment of pit location, or addition of auger holes will be required by the Engineer if a drainage problem exists.

C. Auger Holes: Auger one 6-inch diameter hole through the bottom of each excavated plant hole that does not drain within the specified 24-hour period. Depth of the drill measured from the bottom of the excavation to the bottom of the drill hole shall be 4 feet. Backfill auger holes with 3/4-inch diameter, well-graded drain rock up to bottom of the plant hole. Cover drain rock in the auger hole with 2 feet by 2 feet piece of landscape filter fabric.

3.10 PLANTING, FIVE GALLON OR LARGER PLANTS

A. Stake Plant Locations: Mark tree and shrub locations on Jobsite using stakes or similar means. Make adjustments to locations, where required by the Engineer. Locations shall be approved by the Engineer before plant holes are dug.

B. Planting Holes:

1. Dig pits with vertical sides as indicated.

2. Excavate approximately three times as wide as ball diameter for trees and two times for shrubs.

3. After pits are dug, break the sides to open the wall of the pit for root penetration, and loosen the bottom of the pit to a depth of three inches.

4. Perform a drainage test, as specified in Article 3.09, where required.

5. Construct foot-tamped mound in the bottom of the pit to support the plant at the proper level.

6. Obstructions: Notify Engineer if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.

C. Placement of Plants:

1. Do not handle container plants by the tops, stems, or trunks at any time. Lift plants so that the root ball is supported from the underside. Plants that do not have a satisfactory root system will be rejected.

2. Check for girdling roots, cut and remove if necessary.

3. Cut the root ball vertically in a few places to encourage new feeder root development along the perimeter of the root ball.

4. Plants shall be planted immediately after rootballs are cut.

5. Place each plant in an upright and plumb position.

   a. One and five-gallon size plants shall be set so that the top of the rootball is 1 inch above the finish grade.

   b. Fifteen-gallon size plants shall be set so that the top of the root ball will be 2 inches above the finish grade.

   c. Twenty-four inch and 36-inch box size trees shall have the top of the root ball set 4 inches above the finish grade.

   d. Fifteen gallon, 24-inch box, and 36-inch box trees in planting areas less than 6 feet wide shall have the top of the root ball set 2 inches above the finish grade.

6. Ground cover shall be installed at spacings indicated on Contract Drawings, and shall be evenly spaced and staggered in rows. Place each plant in a pit so that the root system lies free without doubling and so that the roots are planted vertically. Firm the soil around each plant and water the area immediately to avoid drying out.

D. Backfilling:

1. Ensure that proper irrigation is maintained to the rootball. Taper backfill around sides and up to the top of the rootball so that sides of the rootball are not exposed.

2. Construct a four-inch high berm (watering basin) around plant.

3. Backfill shall be watered until the backfill material is moist to the full depth of the hole.

E. Pruning: Pruning shall not be performed unless specifically requested or approved by the Engineer. Examine trees requiring pruning with the Engineer. Trees that are damaged due to improper pruning or wind damage shall be replaced.

F. Staking:

1. Remove the nursery stakes and tags and install specified tree stakes along the sides of the root ball and one foot into undisturbed ground. Stakes shall not go through the root ball.

2. Ties shall be placed as low on the trunk as possible, but high enough so that the tree will return to the upright position after deflection.

3. Ties shall form a loose loop around the tree trunk, and shall be staked so that the trunk cannot work towards the support stakes. Tree ties shall be secured in position in accordance with the manufacturer's recommendations.

4. Support stakes shall not be higher than 6 inches above the tie locations. A flexible auxiliary stake shall be attached to those trees needing extra trunk support as determined by the Engineer.

5. One tree of each size shall be staked and approved by the Engineer prior to continued staking.

6. Trees planted in tree wells with tree grates shall use metal grates stakes or a tree guard. Do not use wood tree stakes.

G. Adjustment of Plants:

1. Plants that settle deeper than specified shall be raised to the correct level.

2. Plants that go out of plumb shall be straightened and re-staked.

H. Watering:

1. Water plantings thoroughly every two to three days as required to establish proper rooting.

3.11 WEED BARRIER (SHEET MULCH) APPLICATION

A. Sheet mulch shall be applied to all planting areas except sodded or seeded areas.

B. Install two layers of recycled cardboard throughout landscaped areas covering existing soil as follows:

1. Wet the cardboard as it is applied to prevent it from blowing away and aid in folding.

2. Do not walk on wet cardboard when it is wet. Tears allow weeds to grow through the barrier.

3. Cardboard sheets shall overlap a minimum 12 inches at joints.

4. Recycled cardboard sheet mulch shall not cover root balls of newly installed plant material.

5. Fold recycled cardboard sheet mulch back and under itself at obstructions. This will avoid excessive cardboard scraps.

6. Provide holes in cardboard for irrigation equipment.

3.12 PLANTING, ONE GALLON PLANTS

A. Do not tear sheet mulch while working.

B. Cut a cross-shaped hole in the sheet mulch to plant.

C. Backfill as indicated in specifications.

D. Top of the plant rootball shall be even with the top of mulch.

E. Do not install watering berms.

3.13 MULCH

A. Install a 3-inch layer of mulch in landscaped areas. Mulch shall be kept 4 inches away from tree trunks and 2 inches from woody shrub stems, and shall be kept off the foliage of ground cover. Install mulch in tree watering basins.

3.14 PRE-EMERGENT HERBICIDES

A. In all areas that are being sheet mulched pre-emergent herbicides are prohibited from use.

B. Pre-emergent herbicides shall be used in all no-mow sod applications.

3.15 SODDING (NO-MOW)

A. See Article 3.2 for soil preparation.

B. Apply pre-emergents to areas to receive no-mow sod .

C. Do not lay weed barrier cardboard or mulch.

D. Lay sod within 24 hours of harvesting. Do not lay sod if dormant or if ground is frozen or muddy.

E. Lay sod to form a solid mass with tightly fitted joints. Butt ends and sides of sod; do not stretch or overlap. Stagger sod strips or pads to offset joints in adjacent courses. Avoid damage to subgrade or sod during installation. Tamp and roll lightly to ensure contact with subgrade, eliminate air pockets, and form a smooth surface. Work sifted soil or fine sand into minor cracks between pieces of sod; remove excess to avoid smothering sod and adjacent grass.

F. Lay sod across angle of slopes exceeding 1:3.

G. Anchor sod on slopes exceeding 1:6 with wood pegs or steel staples spaced as recommended by sod manufacturer but not less than two anchors per sod strip to prevent slippage.

H. Saturate sod with fine water spray within two hours of planting. During first week after planting, water daily or more frequently as necessary to maintain moist soil to a minimum depth of 1-1/2 inches (38 mm) below sod.

3.16 DECOMPOSED GRANITE

A. Install weed barrier where decomposed granite is indicated. The weed barrier shall be tucked into the soil 2 inches deep along the perimeters. Provide 1-foot overlaps at sides and ends. Secure against movement with manufacturer's recommended anchorage staples. Provide cutouts in the weed barrier to accommodate tree staking items and at planting locations.

B. The decomposed granite shall be thoroughly blended with organic binder material at a rate of 10 pounds of binder material per ton of crushed granite screenings. Blending shall be done with a cement mixer, pug mill, or similar equipment prior to placing and spreading the blended decomposed granite over the hand-compacted backfill.

C. The decomposed granite shall be placed in two 1-1/2-inch deep lifts compacted to a minimum of 3-inch depth. Each lift shall be thoroughly moistened with water and then mechanically compacted to a minimum 85 percent relative density, with the finish surface of decomposed granite flush with surrounding curb and sidewalk.

D. Do not install decomposed granite in tree watering basins.

3.17 FIELD QUALITY CONTROL

A. Work specified herein shall be observed by the Engineer. Request observance at least 24 hours in advance of the time such observance is required. Observance is required on the following portions of the work:

1. During preliminary grading and soil preparation;

2. When soil preparation and finish grading has been completed, and before installation of plants;

3. When shrubs and trees are spotted for planting, before planting holes are excavated;

4. When planting and other work has been completed.

B. The Contractor shall require supervisor of landscape planting work to be on the Jobsite at the time of each such observance.

C. Root condition of plants in containers will be inspected by the Engineer by removal of earth from the roots of not less than two plants of each species or variety from each source. Plant materials requiring inspection by the Engineer shall be assembled and available for such inspections. If the sample plants inspected are found to be defective, the Engineer reserves the right to reject the entire lot or lots of plants represented by the defective samples.

D. Rejected plant material shall be removed from the Jobsite and replaced with materials that conform to specified requirements.

3.18 CLEANUP

A. Comply with the requirements of Section 01 74 14, Cleaning.

B. Neatly dress and finish landscaped areas.

C. Broom clean pavements.

3.19 PRELIMINARY INSPECTION

A. At completion of the work of this Section, the Contractor shall request a preliminary inspection to determine the condition of landscaped areas.

B. Inspection shall be requested two working Days in advance.

C. The Contractor and Engineer shall be represented at the inspection.

D. Prior to the preliminary inspection the Contractor shall obtain a third-party irrigation audit per Section 32 84 00, Planting Irrigation. Deficiencies noted in the audit shall be resolved.

E. The irrigation system shall be tested at the preliminary inspection. Refer to Section 32 84 00, Planting Irrigation.

F. Construction considered ready for inspection shall conform to the following requirements:

1. Planting shall be healthy and free of infestations.

2. Landscaped areas shall be free of weeds.

3. Stakes and ties shall be as specified.

4. Mulch shall be raked to a uniform surface.

5. Debris shall be removed from the landscaped area, pavements shall be broom clean, and foliage shall be washed clean.

6. Plants shall be installed in place as indicated and specified.

3.20 PLANT ESTABLISHMENT PERIOD

A. The plant establishment period shall be for a period of one year following the Engineer's written acceptance of the Work after preliminary inspection. Calendar days when the plant establishment period work has not been adequately performed will not be credited as plant establishment period calendar days.

B. Contractor shall meet with the Engineer on a quarterly basis during the plant establishment period to review the work. Contractor shall submit quarterly reports within 10 working days following every field meeting. The plant establishment period may be extended by the Engineer if planted areas are improperly maintained, or other corrective work is not completed per the following requirements. Periodic unscheduled inspections may be made by the Engineer to ensure that proper activities are being conducted. Contractor will be given three Days to complete any corrective action.

C. Contractor shall record all establishment activities and observations in a monthly plant establishment log book that shall be available for review at quarterly meetings. The log book shall be submitted to the Owner on a quarterly basis. Log book shall be organized and include all plant establishment practices outlined below.

D. Tasks shall include watering, cultivating, Integrated Pest Management (IPM), mulch, repair of stakes, cultivation, pruning, and other operations as required to keep the plant material in a healthy growing condition and to keep the planted areas neat and attractive throughout the plant establishment period. Tasks shall include treatment for fungus, diseases, rodents, insects. Tasks shall include but not be limited to the following:

1. Plant Replacement: Until the end of the plant establishment period, any plants that are damaged, diseased, dead, or are in an unhealthy condition exhibiting weakness and the probability of dying, shall be replaced within two weeks. Replacements of plants shall be made in the same manner as specified for the original planting. Contractor shall alert the District immediately to report any vandalism or theft.

2. Guaranty period: Maintain plant materials from the time of planting until the plant materials are well established and are exhibiting a vigorous growth. Plant establishment shall continue until the end of Plant Establishment period per Article 3.20A herein.

3. Mulching: Contractor shall maintain a minimum of 3 inches of mulch at all times over soil surface that is not covered by vegetation. Keep mulch 6 inches away from tree trunks and 4 inches away from shrub stems. Replenish mulch to a 3-inch depth every 6 months and right before final inspection and acceptance. Restore plant basins as needed.

4. Pruning:

    a. Selective Pruning: Plants shall be pruned selectively to remove individual stems or branches that extend beyond the natural conformation of the plant to a lateral branch or at the point of attachment. Woody groundcovers shall be selectively pruned to control growth towards pavements rather than edged. Plants may not overhang into pavement or touch building surfaces.

    b. Hedging and shearing: Contractor shall not sheer plants into formal shapes as this destroys the natural form of the plant and generates excessive waste.

    c. Prior to final acceptance Contractor shall prune trees as needed. Contractor shall have an I.S.A. certified arborist or tree worker present on-site for the duration of tree pruning. Contractor to notify Engineer five Days in advance of this work.

5. Foliage: Rinse foliage of plant materials as often as necessary to keep foliage free of dust.

6. Compost, soil amendments, and fertilizer: Use compost, soil amendments, and fertilizer as specified in Article 2.04 and Article 2.05.

    a. Schedule: Apply compost, soil amendments, and fertilizer per soil analysis report and recommendations. For bidding purposes apply the following:

        1) Top-dress planting with 3/8-inch compost one time per year. Compost to meet Contract Specifications.

        2) Ammonium sulfate (21-0-0) at 5 pounds per 1000 square feet, first application as soon as planting is complete, then at 60-day intervals. Once the landscape has become well established the frequency of fertilization shall be decreased depending on the color and rate of growth desired. In the fall and spring substitute a complete fertilizer such as 16-6-8 to help insure continuing adequate phosphorus and potassium.

7. Watering: Watering shall be adequate to provide maintenance of healthy plant growth, and shall be controlled to prevent over saturation of soil leading to plant failure. Basins, where required, and basin walls shall be kept well formed. Refer to Section 32 84 00, Planting Irrigation.

8. Soil subsidence: Rocks, clods, and debris that appear on the surface shall be removed. Heaved, settled, or eroded areas shall be restored by excavating, addition of topsoil, filling, finish grading, and rolling as required.

9. Protect soil from compaction: Soil may not be worked when wet, generally between October and April. Vehicle access will not be allowed in planting areas during the plant establishment period unless approved by Engineer. If vehicle access is needed over non-paved areas, distribute the load over the soil with 6 inches of coarse organic mulch or reusable planks.

10. Debris removal: Gravel, surplus earth, papers, trash and debris, which accumulate in the landscaped areas and the areas directly adjacent to the paved areas, shall be removed and disposed of weekly. Such areas shall be cared for as required to present a neat and clean condition.

11. Biotreatment area tasks: Clear vegetation from curb cuts as needed to allow positive drainage. Keep trash, debris, sediment, and leaves from all inlets. Adjust rock, cobble, and energy dissipaters as needed to reduce erosion and allow for positive drainage.

12. No-Mow Sod

    a. Mow “no-mow” turf once a year in fall or early spring. Remove clippings from the Jobsite.

    b. Use high weed mower or string line trimmer to mow grasses. Contact sod Supplier to determine appropriate mowing height for species.

    c. Rejuvenating grasses by hard pruning shall only be done when vigorous new growth is imminent.

    d. Contractor shall monitor germination and irrigation frequency and re-sod as needed to ensure a full, dense healthy stand of grass with no weeds or bare spots upon completion of plant establishment period.

13. Vines: Vines adjacent to walls and fences shall be tied and trained as needed to grow on the required surface. Vines may not grow along unwanted surfaces. Prune vines as needed.

14. Tree Staking: Stakes and ties shall be repaired and adjusted as needed.

15. Weeding: Provide weeding, at intervals of not more than 14 Days, as follows:

    a. Weeds which appear in asphalt, concrete, or paved areas within Contract limits shall be removed before they exceed two inches in height or spread.

    b. Weeds in ground cover shall be removed by pulling with roots intact before they exceed four inches in height or spread.

    c. Weeds between basins in areas planted with trees and shrubs shall be removed by pulling before they exceed four inches in height or spread. Weeds shall be removed from within basins, including basin walls, and from within planter boxes.

d. Weed management shall employ Integrated Pest Management (IPM) Approach. Contractor must remove weeds using cultural, mechanical, or physical methods.

1) Monitor planting areas frequently to identify and eradicate weeds early in the growth stage prior to their setting seed.

2) Cut or pull weeds using hand operated equipment where possible.

3) Mow large areas to reduce weed growth and eliminate species that are not tolerant of mowing. Mowing is especially effective when done prior to seed set. Mowing also reduces fire hazard in open spaces.

4) Goats may be used to manage weed growth, where appropriate. Goats shall be well managed, and plants fenced to avoid damaged to non-target plants.

5) Propane-fueled flamers may be used in winter and spring with required permits and approval by the Fire Marshall to kill early-season, non-grass weeds by heating the cells until they burst.

16. Organic Pest Management (OPM): Control pests without harming non-target organisms, or negatively affecting air and water quality and public health.

a. Acceptable controls are as follows:

1) Pruning to remove infected or infested branches and shoots. Time pruning to avoid periods of insect infestation.

2) Removing fallen twigs, leaves, and fruit that contain disease inoculum.

3) Trapping insects using sticky surfaces. Mechanical traps can be used to control rodents.

4) Bacillus thuringiensis (Bt).

5) Parasitic nematodes.

6) Pheromone traps.

7) Beneficial insect release and conservation.

8) Organic pesticides listed in OMRI Generic Materials List.

b. Contractor shall maintain records of all pest management activities. Each record shall include the following information:

1) Target pest;

2) Type and quantity of pesticide used;

3) Site of the pesticide application;

4) Date the pesticide was used;

5) Name of the pesticide applicator;

6) Application equipment used;

7) Prevention and other non-chemical methods of control used.

17. Exported Plant Debris: Do not dispose of plant trimmings in the landfill. Exported plant debris shall be separated from other refuse and taken to a facility where it will be used to produce compost or mulch. Exempt materials include palm fronds, cactus, and poison oak as defined by local regulations.

3.21 FINAL INSPECTION AND ACCEPTANCE

A. Final inspection will be conducted at the end of the plant establishment period 20 to 30 Days before Contract acceptance. Notice requesting final inspection shall be submitted by the Contractor to the Engineer at least seven Days prior to the anticipated date.

B. Prior to final inspection, on the last day of the plant establishment period, complete the weeding and raking of planting areas. Clear Jobsite of debris and present in a neat and orderly condition. Plants shall be in a healthy, thriving condition. Stakes shall be vertical. Paved areas shall be broom cleaned. Areas damaged by erosion shall be repaired.

C. The irrigation system shall be tested at the final inspection. Refer to Section 32 84 00, Planting Irrigation.

D. At the final inspection, the Engineer will determine the condition of the plants and landscape improvements. Acceptance of this work will be contingent upon proper completion of plant establishment period tasks and the establishment of vigorous plant materials. See Article 3.19 for plant replacement protocols.

E. Provide plant replacements within two weeks after final inspection and extend the plant establishment period for an additional 30 Days after replacement planting has been accepted by the Engineer. The Engineer will then repeat the final inspection for the replaced plants at the end of the extended plant establishment period.

END OF SECTION 32 90 00

SECTION 33 05 16

UTILITY STRUCTURES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Excavation and backfill.

B. Cast-in place concrete structures.

C. Precast concrete structures.

D. Metal components.

1.02 RELATED SECTIONS

A. Concrete formwork, concrete reinforcement, cast-in-place concrete, portland cement concrete, concrete repair and finishing, and precast concrete are specified in the various Sections under Division 3 - Concrete.

B. Interior trench drains and gratings for interior uses are specified in Section 05 50 00, Metal Fabrication.

C. Ductbanks are specified in Section 20 50 16, Underground Ductwork and Structures for Facility Services.

1.03 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for utility structures will be either by the lump-sum method or by the unit-price method as determined by the listing of the bid item for utility structures indicated in the Bid Schedule of the Bid Form.

B. Lump Sum: If the Bid Schedule indicates a lump sum for utility structures, the lump-sum method of measurement and payment will be in accordance with Section 01 20 00, Price and Payment Procedures, Article 1.02 Lump Sum Measurement.

C. Unit Price: If the Bid Schedule indicates a unit price for utility structures, the unit-price method of measurement and payment will be as follows:

1. Measurement:

   a. Cast-in-place concrete and precast concrete units or structures and metal curb-and-gutter inlets will be measured for payment by the individual unit (each), installed in place. Each different type and size of concrete unit or structure will be measured separately for payment.

   b. Manhole covers and frames, grates and frames, pipe inlets and outlets, manhole steps, ladders, miscellaneous metal, reinforcing steel, and

grounding will not be measured separately for payment, but will be included as part of the utility structure to which they are attached or embedded.

c. Excavation and backfill for utility structures will be measured separately for payment as specified in Section 31 00 00, Earthwork, as applicable.

2. Payment: Utility structures will be paid for at the indicated Contract unit prices for the computed quantities as determined by the measurement method specified in Article 1.03.C.1, herein.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1.	ASTM A36/A36M	Standard Specification for Structural Steel
2.	ASTM A48/A48M	Standard Specification for Gray Iron Castings
3.	ASTM A108	Standard Specification for Steel Bars, Carbon, Cold-Finished
4.	ASTM A123/A123M	Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
5.	ASTM A153/A153M	Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
6.	ASTM A536	Standard Specifications for Ductile Iron Castings
7.	ASTM B3	Standard Specification for Soft or Annealed Copper Wire
8.	ASTM B26/B26M	Standard Specification for Aluminum-Alloy Sand Castings
9.	ASTM C33	Standard Specification for Concrete Aggregates
10.	ASTM C150	Standard Specification for Portland Cement
11.	ASTM C260	Standard Specification for Air-Entraining Admixtures for Concrete
12.	ASTM C270	Standard Specification for Mortar for Unit Masonry
13.	ASTM C478	Standard Specification for Circular Precast Reinforced Concrete Manhole Sections
14.	ASTM C618	Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
15.	ASTM C1433	Standard Specification for Precast Reinforced Concrete Monolithic Box Sections for Culverts, Storm Drains, and Sewer

16. ASTM C858 Standard Specification for Underground Precast Concrete Utility Structures

17. ASTM C891 Standard Practice for Installation of Underground Precast Concrete Utility Structures

B. California Code of Regulations (CCR):

1. Title 24, Part 2, California Building Code, Chapter 21, Masonry, and State Chapter 21A, Masonry.

C. State of California, Department of Transportation (Caltrans):

1. Bridge Design Specifications Manual, Section 3, “Loads”

D. Underwriters Laboratories Inc. (UL):

1. UL 467 UL Standard for Safety Grounding and Bonding Equipment

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: When not indicated on the Contract Drawings in sufficient detail or definition, submit detailed drawings of cast-in-place and precast concrete utility structures and related metal work.

C. Product Data: Submit manufacturers’ product data for standard manufactured precast concrete utility boxes and structures and for metal gratings and covers and other related miscellaneous metal items.

D. Certification: Submit certification or other acceptable evidence that covers and grates to be provided for roadways and parking areas meet proof-testing requirements for H2O and HS2O loadings in accordance with Caltrans Bridge Design Specifications Manual, Section 3.

PART 2 – PRODUCTS

2.01 CAST-IN-PLACE CONCRETE STRUCTURES

A. Materials: Comply with requirements of Section 03 05 15, Portland Cement Concrete, except as specified otherwise herein.

1. Portland Cement: ASTM C150/C150M, Type II, low alkali.

2. Cementitious Admixture: Provide fly ash or pozzolan conforming with ASTM C618, Class F or N, not to exceed 15 percent by weight of the cement content.

3. Aggregates: ASTM C33/C33M, fine aggregate and Size Nos. 56 or 57 (1-inch maximum size) coarse aggregate.

B. Mix Design: Obtain design of concrete mix as specified in Section 03 05 15, Portland Cement Concrete, and incorporate the following requirements:

1. Concrete Strength: Class 4000 minimum in accordance with Article 3.02, Table 1, of Section 03 05 15, Portland Cement Concrete, except that electrical structures, such as vaults, pull boxes, and concrete for ductbanks, shall be Class 3000.

2. Maximum water-cement plus pozzolan ratio: 0.45.

3. Maximum slump: 4 inches.

2.02 PRECAST CONCRETE STRUCTURES

A. General: The Contractor may provide precast concrete structures that conform to the general configuration, capacities, and inverts indicated.

B. Fabrication Standards: Comply with requirements of Section 03 40 00, Precast Concrete, and ASTM C478, ASTM C1433, and ASTM C858, as applicable, and applicable manufacturers' standards.

C. Materials: Comply with requirements of Section 03 20 00, Concrete Reinforcing, Section 03 05 15, Portland Cement Concrete, and Section 03 40 00, Precast Concrete, except as specified otherwise herein. Provide fine and coarse aggregates conforming to ASTM C33/C33M, in size commensurate with structure and reinforcement clearances.

D. Portland Cement Concrete: Class 4000 minimum in accordance with Article 3.02 Table 1 of Section 03 05 15, Portland Cement Concrete. Concrete may be polymer or latex modified to achieve higher strengths and denser concrete. Concrete shall not deteriorate from chemical attack of sanitary waste.

1. Concrete for electrical utility structures shall be Class 3000.

E. Precast Covers: Precast covers shall have the utility identification, such as "PG&E Gas Valve", "BART H.V. Electrical", "Electrical 480V", "Solar PV", etc, stamped into the cover.

F. Quality Control: In accordance with Section 01 45 00, Quality Control, the Contractor shall perform such inspections and tests as required to verify compliance with these Specifications.

2.03 METAL COVERS, GRATES, AND INLETS

A. Ferrous Castings:

1. Metal used in manufacture of castings shall conform to ASTM A48/A48M, Class 35B for Gray Iron, or ASTM A536, Grade 65-45-12 for Ductile Iron.

2. Castings shall be of uniform quality, free from blowholes, shrinkage, distortion or other defects. Castings shall be smooth and cleaned by shotblasting.

3. Minimum tensile strength shall be 35,000 psi.

4. Castings shall be manufactured true to pattern; component parts shall fit together in a satisfactory manner. Round frames and covers shall have continuously machined bearing surfaces to prevent rocking and rattling.

5. Where castings will be subjected to loads of H-20 or greater, as indicated provide hot dip galvanized steel castings.

B. Aluminum Castings: Where required to reduce weights of larger covers for ease of handling, such covers may be manufactured of aluminum castings conforming to ASTM B26/B26M, Alloy No. 713.0. Minimum tensile strength shall be 32,000 psi.

C. Manhole Covers: Provide cast, manufactured manhole covers and frames with heavy-duty solid cover (lid) or vented cover (lid) as indicated. Covers shall be embossed or engraved with nonslip diamond or square cross-hatched pattern. Provide covers with embossed or engraved word identification, as indicated or appropriate, for the enclosed or underground utility.

D. Grates:

1. Cast Ferrous Grates: Grates for area drains and catch basins shall be heavy-duty, bicycle-safe inlet grates and frames of size and configuration indicated. Grates in roadways and parking areas shall withstand H20 loadings when proof-tested in accordance with Caltrans Bridge Design Specifications Manual, Section 3.

2. Bar-Type Steel Grates: Refer to Section 05 50 00, Metal Fabrications, for requirements. Bar-type steel gratings will be permitted only in areas where vehicular traffic will not be encountered.

E. Curb and Gutter Inlets: Provide cast, manufactured curb inlet frame, grate, and curb box of size and configuration indicated. Curb and gutter inlets shall conform to the contour and profile of the concrete curb and gutter. Grates shall be heavy-duty and bicycle-safe and shall withstand H20.

F. Cast Iron Manhole Steps: Provide cast, manufactured manhole steps with cross-hatched treads and with anchor configuration appropriate for cast-in-place concrete or precast concrete as indicated. Provide steps for installation 12 inches on center in vertical alignment.

2.04 MISCELLANEOUS METAL

A. Requirements: Provide channel inserts, pulling eyes, ladders, and electrical grounding rods for electrical manholes and pull boxes as indicated.

B. Steel Materials: Standard structural sections, shapes, plates, bars, and rods, as indicated, conforming with ASTM A36/A36M. Bars conforming with ASTM 108 will be acceptable.

C. Anchors and Bolts: Conform with requirements of Section 05 50 00, Metal Fabrications, as applicable. Bolts and studs, nuts, and washers shall be hot-dip galvanized in accordance with ASTM A153/A153M.

D. Ladders: Provide standard-manufactured or custom-fabricated steel ladders as required to meet the conditions indicated. Steel ladders shall be hot-dip galvanized after fabrication.

E. Grounding and Bonding Materials: Conform with UL 467 and the following requirements:

1. Grounding Rods: Medium carbon steel core, copper-clad by the molten weld casting process, 3/4-inch diameter by 10 feet long in size.

2. Bare Conductors: ASTM B3, No. 1/0 AWG, Class B stranded, annealed copper conductor.

F. Fabrication: Form and fabricate the work as indicated. Include anchors, fasteners, and accessories to anchor and secure the work in place.

G. Galvanizing: All ferrous metal items shall be galvanized after fabrication by the hot-dip process in accordance with ASTM A123/A123. Weight of the zinc coating shall conform with the requirements specified under “Weight of Coating” in ASTM A123/A123.

2.05 MORTAR

A. Cement mortar for the sealing of openings for pipe penetrations, for cementing of joints of component parts of precast structures, for providing of flow characteristics for the bottoms of drainage structures, and other features as indicated shall conform with the California Building Code, Chapter 21, Type S (without lime), with a minimum compressive strength at 28 days of 1,800 psi.

B. Mortar shall comply with applicable requirements of ASTM C270, including measurement, mixing, proportioning, and water retention. Ten percent by volume of the cement content of the mortar shall be fly ash or pozzolanic material conforming with ASTM C618.

C. Use mortar within 90 minutes after mixing. Discard mortar that has been mixed longer or that has begun to set. Re-tempering of mortar will not be permitted.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Requirements: Construct manholes, junction chambers, catch basins, curb and gutter inlets, trench drains, culverts, headwalls, wingwalls, pull boxes, utility boxes and vaults, and related utility structures in connection with the installation of pipe, conduits, ductbanks, and utility trenches, as indicated.

B. Excavation and Backfill: Provide excavation, prepared subgrade and aggregate base, and backfill as specified in Section 31 00 00, Earthwork, Section 33 05 28, Trenching and Backfilling for Utilities, Section 32 11 17, Aggregate Subbase Courses, and Section 32 11 23, Aggregate Base Course, as indicated.

C. Cast-in-Place Concrete Structures: Provide formwork, steel reinforcement, and concrete in accordance with applicable requirements of Section 03 11 00, Concrete Forming, Section 03 20 00, Concrete Reinforcing, and Section 03 30 00, Cast-In-Place Concrete.

D. Precast Concrete Structures: Install as indicated. Comply with applicable requirements of ASTM C891. Provide such appurtenances and installation accessories, including cement mortar and sealants, as required for a complete installation.

E. Metal Components: Install manhole covers, grates and frames, curb and gutter inlets, metal steps, ladders, channel inserts, pulling eyes, and electrical grounding rods as indicated and in accordance with the respective manufacturer’s instructions. Covers and grates in roadways, parking areas, and concrete walks shall be installed flush with adjacent, abutting pavement.

3.02 FIELD QUALITY CONTROL

A. The Contractor shall perform slump tests and strength tests of cast-in-place structures in accordance with the requirements specified in Section 03 05 15, Portland Cement Concrete.

B. Acceptance of cast-in-place structures will be in accordance with Section 03 05 15, Portland Cement Concrete.

END OF SECTION 33 05 16

SECTION 33 05 25

SUPPORT AND PROTECTION OF UTILITIES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Maintenance, support, and protection of existing underground utilities.

1.02 MEASUREMENT AND PAYMENT

A. Measurement: Maintenance, support, and protection of existing utilities will be measured for payment by the lump-sum method, acceptably performed and completed.

B. Payment: Maintenance, support, and protection of existing utilities will be paid for at the Contract lump-sum price, as indicated in the Bid Schedule of the Bid Form.

1.03 REQUIREMENTS

A. Refer to General Condition, Articles GC4.10, Utilities, GC4.10.4, Location of Utilities, and GC4.10.6, BART System Utilities. It is the Contractor's responsibility to identify and locate existing Utilities from official county and municipal maps and records, District reference documents, and other means. Contractor shall provide utility locating services consisting of alignment and depth and take steps to ascertain the exact location of all Utilities including:

1. PG&E High Voltage lines
2. Fiber Optic and communications cables
3. Electrical cables and conduits (including station conduits and raceways)
4. Water and gas lines
5. Pipelines
6. Sewer mains
7. Fire protection and suppression lines
8. Other BART utilities

B. Utility locating work shall be performed prior to doing any construction work which may damage such Utilities or interfere with their service. Contractor shall obtain Engineer's approval of its "Qualified person", as defined in Government Code 4216, prior to any locating operations. A "Qualified person" means a person who completes a training program in accordance with the requirements of Title 8, California Code of Regulations, Section 1509, Injury Prevention Program, that meets the minimum training guidelines and practices of Common Ground Alliance current Best Practices.

Where the location of a Utility is not indicated or is doubtful, Contactor shall make such excavations and explorations as are necessary to ascertain the correct location. Maintain existing utilities and protect from damage as necessary to satisfy the requirements of jurisdictional utility companies, District facilities and related codes and regulations.

1. The Engineer will furnish the Contractor with two blank 11 inch by 17 inch station maps prior to utility location. The contractor shall hand draw in all found utilities, including type, depth, and alignment, and return one copy to the Engineer prior to the start of Work.

C. Do not disconnect or shut down any part of the existing utilities and services, except by permission of authorities having jurisdiction. Submit schedule of estimated shut-down time in order to obtain such permission, and notify all interested parties, neighbors, utilities, and municipal and county authorities, as required.

D. Utilities to be removed shall not be removed until shut-down time can be kept to a minimum. Do not remove an existing utility line or service until the replacement line, crossover, or capping is ready to be performed.

E. Provide shoring, underpinning, and structural support for existing utility lines and structures that become suspended or otherwise unsupported because of adjacent excavation operations. Submit plans showing all protections in place and temporary supports of utilities adequate to maintain safety, integrity and function for Engineer's review and approval.

1.04 REQUIRED NOTIFICATIONS

A. Obtain identification markings of underground utilities by the affected utility companies 72 hours prior to performing any excavation or other work close to any underground pipeline, conduit, duct, wire, or other structure. The Contractor shall notify the Engineer and utility owners before performing any such excavation work. Notify most affected utilities by calling Underground Service Alert (USA) at 1-800-642-2444. Contact utility owners not covered by USA, such as owners of non-pressurized sewer lines and Caltrans, by calling the affected utility owners directly.

B. Protect active underground utilities from damage. If underground utilities are damaged in any way, notify the Engineer and affected utilities immediately for corrective action. The names of known utility companies in the area and their respective addresses and telephone numbers are specified as attachments to this section.

1.05 RELOCATION OF EXISTING UTILITIES

A. It is anticipated that certain utilities will be relocated by the affected utility companies prior to start of construction. The names and addresses of such utility companies, including a list of facilities to be relocated with description and location, are specified as an attachment to this section.

PART 2 – PRODUCTS

Not Used

PART 3 – EXECUTION

Not Used

END OF SECTION 33 05 25

SECTION 33 05 28

TRENCHING AND BACKFILLING FOR UTILITIES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Bedding and backfilling materials.

B. Staking and grades.

C. Existing utilities.

D. Trenching and excavating.

E. Bedding and backfilling.

1.02 RELATED SECTIONS

A. Facility services is specified in Section 20 50 13, Raceways for Facility Services.

B. Earthwork is specified in Section 31 00 00, Earthwork. The work of this Section shall conform with the requirements of Section 31 00 00, Earthwork, as applicable.

C. Dewatering is specified in Section 31 23 19, Dewatering.

D. Excavation support systems are specified in Section 31 50 00, Excavation Support and Protection.

E. Foundation drains and other subsurface drainage are specified in Section 33 46 00, Subdrainage.

F. Electrical Lighting Details – Standard Drawing ES77

1.03 MEASUREMENT AND PAYMENT

A. Measurement: Trenching and backfilling for utilities will not be measured separately for payment.

B. Payment: Trenching and backfilling for utilities will be paid for as part of the indicated Contract unit prices for the associated piping, conduits, ductbanks, and utility structures.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM C33/C33M Standard Specification for Concrete Aggregates

B. State of California, Department of Transportation (Caltrans), Standard Specifications, Section 96, Geosynthetics

C. State of California, Department of Transportation (Caltrans), Office of Structure Construction, “Trenching and Shoring” Manual

D. State of California, Department of Transportation (Caltrans), Office of Encroachment Permit, “Encroachment Permit”

1.05 DESCRIPTION

A. This Section includes specifications for excavating, trenching, and backfilling for utilities and related structures, as indicated in the Contract Documents, including underground piping for water supply, sanitary and storm sewerage piping; trackway and roadway site subsurface and drainage piping; underground electrical conduits and ductbanks; and utility boxes, catch basins, manholes, inlets, pull boxes, and vaults.

1. Trenching and backfilling for utilities includes restoration of existing pavements, where applicable, to the conditions existing before the excavation. Conform with applicable requirements of Section 32 12 16, Asphalt Paving, Section 32 13 13, Concrete Paving, and Section 32 16 21, Concrete Curbs, Gutters, and Walks.

1.06 REGULATORY REQUIREMENTS

A. Regulatory requirements that govern the work of this Section include the following governing codes:

1. California Code of Regulations (CCR), Title 8, Division 1, Chapter 4, Subchapter 4 — Construction Safety Orders, for trench excavations of 5 feet or more in depth.

2. California Code of Regulations, Title 24, Part 2, California Building Code, Chapter 33, Safeguards During Construction, for protection of the public.

3. State of California Public Utilities Commission (CPUC):

   a. CPUC General Order (G.O.) 128, Rules for Construction of Underground Electric Supply and Communications Systems

1.07 SUBMITTALS

A. Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures. Submittals for trenches of 5 feet or more in depth shall be submitted to the Engineer for review and approval.

B. Submit drawings and supporting calculations for trench excavations and support systems of 5 feet or more in depth in accordance with the submittals requirements of Section 31 50 00, Excavation Support and Protection. All such submittals shall be prepared, sealed, and signed by a professional civil or structural engineer currently registered in the State of California.

PART 2 – PRODUCTS

2.01 BEDDING AND BACKFILLING MATERIALS

A. Bedding:

1. Sand: Sand for bedding of pipe in utility trenches shall be a clean and graded, washed sand, all passing a No. 4 U.S. Standard sieve, and conforming generally to ASTM C33 for fine aggregate. A finer sand may be used, provided the sand is clean and does not contain deleterious substances in excess of the amounts specified in ASTM C33/C33M, Table 3.

    a. Only sand will be permitted for bedding of electrical conduit.

2. Class 2 Aggregate Base for bedding of pipe in trenches shall conform to the requirements in Section 32 11 23, Aggregate Base Course.

3. For electrical conduits refer to BART Standard Drawing ES77, Electrical Lighting Details.

B. Backfill Material:

1. Backfill for excavations and trenches under structures shall be Structural Fill as indicated. (Refer to Section 31 00 00, Earthwork, for requirements.)

2. Backfill for excavations and trenches under pavement shall be either Class 2 Aggregate Base or Controlled Density Fill:

    a. Class A Aggregate Base shall conform to the applicable requirements of Section 32 11 23, Aggregate Base Course.

    b. Controlled Density Fill shall consist of a fluid, workable mixture of portland cement, clean and graded aggregate, and water. Refer to Section 31 23 25, Controlled Density Fill, for requirements.

3. Common Fill will be permitted only for backfilling of excavations and trenches in open areas and landscaped areas.

4. For electrical conduits refer to BART Standard Drawing ES77, Electrical Lighting Details.

C. Filter Fabric: Geotextile engineering fabric conforming to Caltrans Standard Specifications, Section 96, Geosynthetics.

PART 3 – EXECUTION

3.01 STAKING AND GRADES:

A. Refer to Section 31 00 00, Earthwork, for requirements.

3.02 EXISTING UTILITIES:

A. Refer to Section 33 05 25, Support and Protection of Utilities, and Section 31 00 00, Earthwork, for requirements.

3.03 TRENCHING AND EXCAVATING

A. Comply with the California Building Code, Chapter 33, as applicable.

B. Perform trenching and excavation as indicated and required for drainage and utility piping, conduits, and related structures, and provide shoring, bracing, pumping, and planking as required and as specified in Section 31 50 00, Excavation Support and Protection.

C. Excavate to the lines and grades indicated.

D. Excavate trenches for pipes and conduits by the open-cut method, except where tunneling or jacking are indicated. Hand-excavate for crossing pipelines.

E. In paved areas, saw cut pavement in straight lines. Saw cut pavement 1 foot outside the trench line to the depth of the pavement structural section. After compacting the backfill, restore pavement to a condition equivalent to that existing at the start of construction. Restore pavement damaged outside the straight lines.

1. Where indicated or required by the governmental authority having jurisdiction, provide slurry cement backfill for trench excavation to underside of pavement.

F. When distance between trench and lip of gutter or edge of pavement is 4 feet or less, the asphalt concrete pavement section shall be replaced and overlaid up to the lip of gutter.

G. Excavate trenches to the indicated width at all points below a horizontal plane 2 feet above the top of the pipe. Excavation above this plane may exceed the indicated width as required. Where the width is not indicated, make the width not less than 6 inches nor more than 18 inches from the outside of the pipe. If the excavation exceeds permissible dimensions, install higher strength pipe or encase the pipe in Class 3000 concrete.

H. The bottoms of excavations shall be firm, undisturbed earth or cut sub grade, clean and free from loose material, debris, and foreign matter. When bottoms of excavations or trenches are a soft or unstable material, the bed shall be made firm and solid by removing said unstable material to a sufficient depth and replacing same with sand, compacted to at least 90 percent relative compaction.

I. Where water is encountered in the trench, dewater as specified in Section 31 23 19, Dewatering, and provide sand or pea gravel as required to drain the water and stabilize the bed.

J. Bell holes shall be accurately placed and shall not be larger than required to make the joint.

K. When backfilling operations of an excavation under pavement cannot be properly completed within a work day, provide steel plate bridging with a non-skid surface and shoring to preserve unobstructed traffic flow.

1. Trench Plates shall comply with the Caltrans Encroachment Permit Manual Section 602.5C Temporary Steel Plate Bridging—With a Non-Skid Surface.

   a. Trench Plates shall be installed by Method 1.

   b. The duration shall be approved by the Engineer.

3.04 BEDDING AND BACKFILLING

A. Minimum thickness of sand bedding under concrete pipe shall be 2 inches. Provide firm and uniform support of piping at indicated elevations and grades. Tamp sand bedding as required for firm support.

1. The joints of gravity flow piping shall be wrapped with filter fabric all around the pipe. Place filter fabric under the pipe before laying pipe in sand bedding. Filter fabric shall extend at least 12 inches on each side of the joint.

B. Place applicable backfill below the horizontal centerline of pipe to 12 inches above the top of pipe.

C. Backfill shall be placed in 6-inch layers, leveled, rammed, and tamped in place. Each layer shall be compacted with suitable compaction equipment to at least 90 percent relative compaction, taking care not to damage or misalign any pipe. The top 12 inches under structures and pavement shall be compacted to at least 95 percent relative compaction.

D. Backfilling around concrete structures and for ductbanks and similar utilities shall conform to the applicable requirements of Section 31 00 00, Earthwork.

3.05 FIELD QUALITY CONTROL

Comply with applicable requirements specified in Section 31 00 00, Earthwork.

END OF SECTION 33 05 28

SECTION 33 11 00

WATER UTILITY DISTRIBUTION PIPING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Buried pipe and fitting.

B. Valves.

C. Fire hydrants.

D. Thrust blocks and harnessing.

E. Field quality control.

F. Test.

G. System disinfection.

H. Connections to existing mains.

1.02 RELATED SECTIONS

A. Section 03 05 15, Portland Cement Concrete

B. Section 09 91 00, Painting

C. Section 22 11 01, Water Distribution

D. Section 28 31 00, Fire Detection and Alarm System

E. Section 31 00 00, Earthwork

F. Section 33 05 16, Utility Structures

G. Section 33 05 28, Trenching and Backfilling for Utilities

1.03 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for the water distribution system will be either by the lump-sum method or by the unit-price method as determined by the listing of the bid item for the water distribution system indicated in the Bid Schedule of the Bid Form.

B. Lump sum: If the Bid Schedule indicates a lump sum for the water distribution system, the lump-sum method of measurement and payment will be in accordance with Section 01 20 00, Price and Payment Procedures, Article 1.02 Lump Sum Measurement.

C. Unit price: If the Bid Schedule indicates a unit price for the water distribution system, the unit-price method of measurement and payment will be as follows:

1. Measurement:

a. Water distribution system will be measured for payment by the linear foot of pipe, installed in place, tested and disinfected, for each type and size of pipe, along the centerline of the pipe with deductions made for manholes or other structures, measured from the inside face of each structure.

b. Utility structures will be measured separately for payment as specified in Section 33 05 16, Utility Structures.

c. Pipe fittings, valves, joints, pipe bedding, collar taps, and cutting of pipe will not be measured separately for payment, and all costs in connection therewith will be considered as included in the linear foot measurement for pipe.

d. Fire hydrants will be measured for payment by the individual unit (each), installed in place and acceptably tested.

e. Support of trench excavation, maintenance, support of existing utility facilities, grading, excavation and backfill, cast-in-place concrete, and incidental work pertaining to the installation of pipe will not be measured separately for payment, but will be considered as included in the linear foot measurement for pipe.

2. Payment: The water distribution system will be paid for at the indicate Contract unit prices for the computed quantities as determined by the measurement method specified in Article 1.03.C.1.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1.	ASTM A126	Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
2.	ASTM A197/A197M	Standard Specification for Cupola Malleable Iron
3.	ASTM A307	Standard Specification for Carbon Steel Bolts, Studs and Threaded Rods, 60,000 psi Tensile Strength
4.	ASTM D1784	Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds
5.	ASTM D1785	Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
6.	ASTM D2466	Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40

7. ASTM D2564 Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems

8. ASTM D2855 Standard Practice for the Two-Step (Primer and Solvent Cement) Method of Joining Poly (Vinyl Chloride) (PVC) or Chlorinated Poly (Vinyl Chloride) (CPVC) Pipe and Piping Components with Tapered Sockets

9. ASTM D3139 Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals

10. ASTM F439 Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80

11. ASTM F477 Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe

B. American Water Works Association (AWWA):

1. AWWA C500-09 Metal Seated Gate Valves for Water Supply Service

2. AWWA C503-14 Wet-Barrel Fire Hydrants

3. AWWA C651-14 Disinfecting Water Mains

4. AWWA C900-07 Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 in. through 60 in. (100 mm through 1,500 mm)

C. Underwriters Laboratories Inc. (UL):

1. UL 246 UL Standard for Safety Hydrants for Fire-Protection Service

D. Manufacturer's Standardization Society (MSS):

1. MSS SP-70 Gray Iron Gate Valves, Flanged, and Threaded Ends

2. MSS SP-80 Bronze Gate, Globe Angle, and Check Valves

3. MSS SP-85 Gray Iron Globe and Angle Valves, Flanged and Threaded Ends

1.05 SUBMITTALS

A. Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Submit respective manufacturer's product data for manufactured materials and equipment, including all valves and fire hydrants.

C. Submit Shop Drawings showing piping layout and pipe, valves, hydrants, and locations of tie-ins, buttresses, and thrust blocks.

1.06 SUBMITTALS FOR CLOSEOUT

A. General: Refer to Section 01 77 00, Closeout Procedures, and Section 01 78 23, Operation and Maintenance Data, for submittal requirements and procedures.

B. Record Drawings: Record actual location of piping mains, valves, connections, and invert elevations for review.

1.07 QUALITY ASSURANCE

1.08 SITE CONDITIONS

A. Excavations in which products will be buried shall be dry.

B. Coordinate the installation of the water supply system with the jurisdictional water utility owner.

C. The jurisdictional water utility district shall provide water services to the water meters' points of connection for station facilities and landscape irrigation systems, and modifications to existing water mains, as indicated on the Contract Drawings. The Contractor shall be responsible for making all such arrangements.

PART 2 – PRODUCTS

2.01 BURIED PIPE AND FITTINGS

A. Requirements: Provide the types, sizes, and configurations of pipe, fittings, and miscellaneous materials and installation accessories as indicated.

B. PVC Pipe and Fittings, 3 Inches and Smaller:

1. Pipe: Polyvinyl chloride (PVC), ASTM D1785, Schedule 40 or 80, as indicated, Type I, Grade 1.

2. Fittings: ASTM D2466, socket weld, same material and schedule as pipe, or meeting requirements of ASTM F439, as applicable.

3. Joints: Socket welded with PVC solvent cement conforming to ASTM D2564 and ASTM D2855.

C. PVC Pipe and Fittings, 4 Inches and Larger:

1. Pipe: AWWA C900, Class 200, polyvinyl chloride (PVC) water pipe with bell and spigot ends and flexible ring joints.

2. Fittings: ASTM D1784, Type 1, Grade 1, polyvinyl chloride (PVC) fittings, Class 200, or meeting requirements of ASTM F439, as applicable.

3. Joints: ASTM D3139, gasketed bell joints with ASTM F477 gaskets.

D. Tracer Wire: Stranded copper AWG No. 10 with U.S.E. rated insulation. Color: Black.

E. Reflective Warning Tape.

2.02 VALVES

A. Gate Valves:

1. Gate Valves up to 2 1/2 Inches: 150 pound bronze body, non-rising stem, single wedge, threaded connection.

2. Gate Valve 3 Inches and Over: AWWA C500, iron body, bronze trim, non-rising stem with square nut, single wedge, mechanical joint ends with type gland and serration's designed for plastic pipe service.

B. Pressure Reducing Valves: MSS SP-80 valves, 2 inches and smaller, shall be all bronze construction meeting the requirements of MSS SP-80. MSS SP-85 valves, 2 1/2 inches and larger, shall be all cast iron construction meeting the requirements of MSS SP-70. Valves 2 1/2 inches and smaller shall have threaded connections. Valves 3 inches and larger shall have flanged connections. Valves shall be stainless steel spring-loaded, single-seated, and suitable for tight shutoff under dead-end conditions. Provide with renewable stainless steel seat, nylon inserted diaphragm, and bolted spring chamber. Valves shall be rated for 300 pounds per square inch (psi) working pressure, adjustable from 25 to 75 psi, factory set at 50 psi. Pressure gauges (or gauge ports) shall be installed upstream and downstream of pressure-reducing valve. Tamper switches shall be installed on pressure reducing valves for all fire protection services only. Valves shall be monitored either by the fire alarm system if one is installed at the facility, or directly by SCADA at locations not monitored by a fire alarm system.

C. Backflow Preventer: Provide device, which is approved by the jurisdictional water utility company. As a minimum, backflow preventer shall be a reduced pressure principle assembly. Backflow preventer shall be suitable for 175 pounds per square inch (psi) operating pressure and 140 degrees Fahrenheit operating temperature. Backflow preventer shall be of bronze construction with screwed inlet and outlet for 2 inch and smaller sizes and cast iron epoxy-coated construction with 150 pound flanged inlet and outlet for 2 1/2 inch and larger sizes. For irrigation, for size two inches and smaller provide Febco LF825YA, District Designated Matching Product. Tamper switches shall be installed on valves of backflow preventers for all fire protection services only. Valves shall be monitored either by the fire alarm system if one is installed at the facility, or directly by SCADA at locations not monitored by a fire alarm system.

D. Tamper Switches: Supervised tamper switches shall be provided for valves in all fire protection services per NFPA requirements.

2.03 FIRE HYDRANTS

A. Provide fire hydrants and related appurtenances as indicated. Fire hydrants shall comply with the requirements of the jurisdictional authority and the standard drawings and specifications of the jurisdictional water utility district, as applicable.

B. Fire hydrants shall meet the requirements of AWWA C503 and UL 246, as applicable, and shall be wet barrel type, as a minimum, with a minimum of two discharge nozzles of size(s) required by the jurisdictional authority.

2.04 CONCRETE FOR THRUST BLOCKS

A. Provide Class 3000, 1 inch aggregate, concrete for all thrust blocks, as specified in Section 03 05 15, Portland Cement Concrete, with reinforcement where indicated.

2.05 MISCELLANEOUS METAL

A. Tie Rods: Stainless steel, Type 316, threaded ANSI standard, bolt threaded on both ends. Minimum 1/2 inch diameter for 4 inch pipe, 5/8 inch minimum diameter for 6 inch and 8 inch diameter pipe, and 3/4 inch minimum diameter for 12 inch and larger.

B. Rod Couplings: Malleable iron, ASTM A197/A197M, turnbuckle design, female threaded to mate with tie rods, 5/8 inch and 3/4 inch sizes to mate with both rods and mechanical joint bolts.

C. Pipe Clamps: For sizes 4 inches and larger, provide with malleable iron rod sockets. Provide washers in lieu of rod sockets where authorized, conforming with ASTM A126, Class A, cast iron. Bolts and bolting shall conform with ASTM A307.

PART 3 – EXECUTION

3.01 MAINTAINING WATER SERVICES

A. Maintain water service and conduct operations at times selected to minimize the duration and inconvenience of service interruption.

B. At least 24 hours prior to the required cutting or abandoning of an existing water main, notify the jurisdictional water utility owner, and obtain approval of the schedule. Actual cutting or abandoning of an existing water main shall be performed by the Contractor after receiving approval from the owner of the facility.

C. Keep existing water mains parallel to new water mains in service until new water mains are ready for service.

D. Where the existing water main or service is to be cut for connection to new piping, the work shall be performed by the Contractor. Initial work operations shall include the test-pitting of all points of connection (tie-in) to ensure the true location of existing linework.

E. Water valves in service shall be operated only by personnel of the jurisdictional water utility owner.

F. Except as specified otherwise herein, construction methods shall be in accordance with the applicable provisions of the jurisdictional water utility owner's standard drawings and specifications.

3.02 INSTALLATION

A. Coordinate the work with Section 22 11 01, Water Distribution.

B. Installation Requirements:

1. Excavate pipe trench in accordance with Section 33 05 28, Trenching and Backfilling for Utilities. Hand trim bottom of trench to approximately 6 inches below invert of pipe.

2. Top of pipe to finished grade shall be minimum 36 inches unless otherwise indicated or approved by the Engineer.

3. Minimum depth from top of pipe to subgrade shall be 18 inches without concrete cap, unless otherwise approved by the Engineer.

4. Place bedding material, meeting the requirements of Section 33 05 28, Trenching and Backfilling for Utilities, at trench bottom, level in one continuous layer not exceeding 8 inches in compacted depth. Compact bedding to 95 percent relative density.

5. Backfill around sides and to 6 inches above pipe with cover fill tamped in place and compacted to 95 percent relative density.

6. Test pipe distribution system and place tracer wire on top of pipe as specified herein prior to covering pipe. Backfill trench in accordance with Section 33 05 28, Trenching and Backfilling for Utilities.

7. Maintain optimum moisture content of bedding material to attain required compaction density.

8. Provide concrete thrust blocks for elbows, tees, valves, and appurtenances of buried piping. Thrust blocks shall be constructed as indicated and in accordance with AWWA requirements.

9. Install piping true to line and grade, supported and guided to assure alignment under all conditions.

10. Install pipe to allow for expansion and contraction without stressing pipe or joints.

11. Install unions at each connection to valves, both sides of each valve.

12. Make change in line with fittings. Do not spring joints to effect change of direction.

13. Do not field cut pipe unless necessary. Make such necessary cuts by means of equipment designed for the purpose, ensuring a smooth and square end.

14. For connection to existing pipe, provide pipe with suitable ends or adapters, after verification of size and type of existing pipe.

15. Install tie rods and pipe clamps at every joint fitting and valve.

C. Valves:

1. Install valves in accordance with the valve manufacturer's installation instructions.

2. Where valves are provided by the jurisdictional water utility owner, provide suitable access for performance of such work.

3. Where necessary, alter the typical valve manhole to suit actual conditions. Any alterations in valve manholes shall be operable from the street level. All operator nuts shall be plumb to the valve manholes.

4. Set valve on solid bearing.

5. Center and plumb valve box over valve. Set box cover flush with finished grade.

D. Fire Hydrants:

1. Provide fire hydrant installations as indicated. Installation shall conform with requirements of the jurisdictional fire department and the Contract Drawings and specifications.

2. Provide necessary appurtenances and accessories as required to complete the installation.

3. Paint hydrants in accordance with applicable requirements of Section 09 91 00, Painting.

4. Set hydrants plumb, locate pumper nozzle perpendicular to and facing roadway.

E. Thrust Blocks and Harnessing:

1. Provide for counteracting thrust caused by static and dynamic forces, including water hammer at bends, tees, reducers, valves, and dead-ends by installing harnessing as indicated or required. For other methods, submit details for approval of the jurisdictional water utility owner prior to use.

2. Provide concrete thrust blocks as indicated where harnessing is not practicable.

F. Tracer Wire: Stranded copper AWG No. 10 with U.S.E. rated insulation. Color: Black.

G. Reflective warning tape: After installation of bollards, install three strips of reflective warning tape 1 inch wide and 6 inches apart from the top of the bollard.

H. Water Service Connections: Provide water service connections, where necessary, in accordance with the California Plumbing Code, the installation instructions of the service pipe and fittings manufacturer, and the utility company requirements with reduced pressure back-flow preventer and water meter with by-pass valves.

I. Acceptance Requirements: After installation of pipes, ends of pipes shall be either capped or plugged. No piping shall be buried before being inspected and tested.

3.03 FIELD QUALITY CONTROL

A. Refer to Section 01 43 00, Quality Assurance, for requirements.

B. Compaction testing of related earthwork shall be performed in accordance with applicable requirements of Section 31 00 00, Earthwork.

C. If tests indicate work does not meet specified requirements, remove such work, replace, and retest at no additional cost to the District.

3.04 TESTS

A. Protection from Flooding: Provide positive measures to protect exposed, installed pipe and compacted pipe bedding from flooding during testing.

B. Notice of Testing:

1. Give notice of intention of testing to the jurisdictional water utility owner as required, or no less than 48 hours, which will furnish, install, and operate pumps, gauges, meters, and individual pipe connections to test openings.

2. Designate largest sections feasible for testing and sterilizing. Testing and sterilizing operations shall be performed by the Contractor; at Contractor's expense.

C. Testing Requirements:

1. General:

a. Prior to backfilling, isolate the system by use of approved valves, caps and plugs, or other acceptable methods.

b. Maintain such isolation throughout the performance of leakage and pressure testing.

c. Where valves are used for isolation, eliminate leakage through such valves if it occurs. Maintain new work isolated from existing water mains, except for test connections, until testing and sterilization have been completed.

2. Hydrostatic Tests:

   a. For hydrostatic tests, provide approved caps and plugs in sections to be tested, and remove them after testing.

   b. Prevent leakage in pipes and fittings at openings. Temporarily block plugged and capped ends to prevent displacement.

   c. Install the water source connection for testing the isolated section. The Engineer may permit the use of a tap that will be furnished and installed by utility owner.

   d. Provide labor and materials required for leakage testing, including excavation for installation and removal of pumps, gauges, meters, and water source connections.

   e. Where leakage exceeds the water utility company's standards, perform necessary corrective measures.

   f. Remove and replace defective pipes, joints, fittings, valves, and other appurtenances. Reset such items if displaced.

   g. Perform hydrostatic tests in accordance with the jurisdictional water utility district's requirements. All such tests shall be witnessed by the jurisdictional water utility district's representative. The Contractor shall be responsible for making all such arrangements.

   h. Remove and replace defective pipe, joints, fittings, valves, and other appurtenances. Reset such items if displaced.

D. Testing and Flushing of Potable Water System: Test the potable water system hydrostatically in sections to a pressure of at least 150 pounds per square inch (psi) for not less than 15 minutes, witnessed by the Engineer. Pressure test pipe before burial. Repair leaks and retest the system until the system is leak free. Use testing instruments calibrated by a qualified laboratory in accordance with Section 01 45 00, Quality Control. Test sequence shall be as follows:

   1. Lines shall be fully flushed.

   2. Lines shall be hydrostatically tested.

   3. Lines shall be fully disinfected.

3.05 SYSTEM DISINFECTION

A. Before final acceptance of the water supply system, each section of the new line shall be disinfected in accordance with AWWA C651 and in accordance with the jurisdictional water utility District's requirements, if applicable. One of the following sources of disinfectant shall be used:

   1. Mixture of water and chlorine gas;

   2. Direct application of chlorine;

3. Mixture of water and calcium hypochlorite; or

4. Mixture of water and calcium chloride.

B. Before disinfecting, flush the line thoroughly to remove dirt and extraneous materials. Clean each section of the line between valves independently.

C. Retain the disinfectant solution in the pipe for at least 24 hours. Following this sterilization period, the residual chlorine content at the ends of the section and at other representative points shall be not less than five parts per million. Then, the line shall be drained and thoroughly flushed with water until the residual chlorine content is similar to that obtained from the existing water distribution system.

D. Take water samples and test in accordance with AWWA C651.

3.06 CONNECTIONS TO EXISTING MAINS

A. Following testing and sterilization, new water distribution lines shall be connected to existing mains as indicated. Each connection shall be made at a time and in a manner that will result in the least interruption of service.

B. All connections involving shut down of jurisdictional water utility's existing facilities shall be made under the immediate supervision of the jurisdictional water utility district. No member of the Contractor's forces may operate any valve controlling the flow of water in the water utility's existing system.

C. The Contractor shall provide tie-ins to the existing system at a time that is convenient to jurisdictional water utility district, which may be in the evenings and on weekends.

END OF SECTION 33 11 00

SECTION 33 31 00

SANITARY UTILITY SEWERAGE PIPING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Buried Pipe and Fittings.

B. Cleanouts.

C. Sewage Ejector.

D. Field Quality Control.

1.02 RELATED SECTIONS

A. Section 22 13 01, Sanitary Sewerage

B. Section 22 14 29, Sump Pumps

C. Section 31 00 00, Earthwork

D. Section 33 05 16, Utility Structures

E. Section 33 05 28, Trenching and Backfilling for Utilities

1.03 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for the site sanitary sewerage system will be either by the lump-sum method or by the unit-price method as determined by the listing of the bid item for the site sanitary sewerage system indicated in the Bid Schedule of the Bid Form.

B. Lump Sum: If the Bid Schedule indicates a lump sum for the site sanitary sewerage system, the lump-sum method of measurement and payment will be in accordance with Section 01 20 00, Price and Payment Procedures, under Article 1.02 Lump Sum Measurement.

C. Unit Price: If the Bid Schedule indicates a unit price for the site sanitary sewerage system, the unit-price method of measurement and payment will be as follows:

1. Measurement:

a. Site sanitary sewerage system will be measured for payment by the linear foot of pipe, installed in place and tested, for each type and size, along the centerline of the pipe, with deductions made for manholes or other structures, measured from the inside face of each structure.

b. Utility structures will be measured separately for payment as specified in Section 33 05 16, Utility Structures.

c. Pipe fittings, joints, pipe bedding, cleanouts, collar taps, and cutting of pipe will not be measured separately for payment, and all costs in connection therewith will be considered as included in the linear foot measurement for pipe.

d. Support of trench excavation, maintenance, support of existing utility facilities, excavation and backfill, concrete, and incidental work pertaining to the installation of sewer pipe will not be measured separately for payment, but will be considered as included in the linear foot measurement for sewer pipe.

2. Payment: Site sanitary sewerage system will be paid for at the indicated Contract unit prices for the computed quantities as determined by the measurement method specified in Article 1.03.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM C14 Standard Specification for Nonreinforced Concrete Sewer, Storm Drain, and Culvert Pipe

2. ASTM C76 Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe

3. ASTM C443 Standard Specification for Joints for Concrete Pipe and Manholes, using Rubber Gaskets

4. ASTM D1785 Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120

5. ASTM D2466 Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings, Schedule 40

6. ASTM D2564 Standard Specification for Solvent Cements for Poly (Vinyl Chloride (PVC) Plastic Piping Systems

7. ASTM D2855 Standard Practice for the Two-Step (Primer and Solvent Cement) Method of Joining Poly (Vinyl Chloride) (PVC) or Chlorinated Poly (Vinyl Chloride) (CPVC) Pipe and Piping Components with Tapered Sockets

8. ASTM D3034 Standard Specification for Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings

9. ASTM D3139 Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals

10. ASTM F477 Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe

11. ASTM F1336 Standard Specification for Poly (Vinyl Chloride) (PVC) Gasketed Sewer Fittings

B. American Water Works Association (AWWA):

1. AWWA C900 Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 in. through 60 in. (100 mm through 1,500 mm)

2. ANSI/AWWA C111/A21.11 Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings

1.05 SUBMITTALS

A. Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Submit Shop Drawings showing piping layouts, sizes, types, cleanouts, and the sewage structure ejector station.

C. Submit the respective manufacturers' product data for manufactured materials and equipment.

D. Submit equipment manufacturer's printed operating and maintenance instructions in accordance with Section 01 78 23, Operation and Maintenance Data, consisting of a detailed parts list, a recommended spare parts list, and complete operation and maintenance procedures.

E. Submit certified test reports of equipment, as applicable.

1.06 SUBMITTALS FOR CLOSEOUT

A. Refer to Section 01 77 00, Closeout Procedures, and Section 01 78 39, Project Record Documents, for submittal requirements and procedures.

B. Record actual location of piping mains, valves, connections, thrust restraints, and invert elevations.

1.07 SITE CONDITIONS

A. Excavations shall be dry immediately before and after products are installed. Provide surfaces and structures to, and on which sewerage products will be installed.

B. Coordinate the installation of the sanitary sewerage system with the jurisdictional sanitary district or utility owner.

PART 2 – PRODUCTS

2.01 BURIED PIPE AND FITTINGS

A. Requirements: Provide the types, sizes, and configurations of pipe, fittings, and miscellaneous materials and installation accessories as indicated and required. Pipe ends shall be bell and spigot, except plain end pipe shall be joined with mechanical clamp and gasket joint.

B. PVC Pipe and Fittings, 3 Inches and Smaller:

1. Pipe: Polyvinyl chloride (PVC), conforming with ASTM D1785, Schedule 40 or 80, as indicated, Type I, Grade 1, bell and spigot style solvent sealed jointed.

2. Fittings: ASTM D2466, Socket Weld, same material and schedule as pipe.

3. Joints: Socket welded with PVC solvent cement conforming with ASTM D2564 and ASTM D2855.

C. PVC Pipe and Fittings, 4 Inches and Larger:

1. Pipe:

- AWWA C900, Class 200, Poly (Vinyl Chloride) (PVC) Water Pipe with Bell and Spigot Ends and Flexible Ring Joints.
- Fittings: ASTM D2466, Type 1, Grade 1, Poly (Vinyl Chloride) (PVC) Fittings, Class 200.
- Joints: ASTM D3139 gasketed bell joints with ASTM F477 gaskets.
- SDR 26, PVC pipes, fittings, couplings and joints shall meet the requirements of ASTM D3034.
- Fittings: ASTM F1336.
- Joints: ASTM D213 bell-and-spigot with ASTM F477 gaskets .

D. Reinforced Concrete Pipe:

1. Pipe: ASTM C76, Class III, with steel reinforcement.

2. Joint Device: ASTM C443, rubber compression gasket joint.

E. Pipe Accessories:

1. Pipe Joints: Mechanical clamp ring type, stainless steel expanding and contracting sleeve, with neoprene ribbed gasket for positive seal.

2. Fittings: Same material as pipe molded or formed to suit pipe size and end design, in required tee, bends, elbows, cleanouts, reducers traps, and other configurations as indicated or required.

F. Pipe Bedding Material: As specified in Section 33 05 28, Trenching and Backfilling for Utilities.

2.02 CLEANOUTS

A. At grade cleanouts shall have an adjustable sleeve-type housing, a threaded brass plug with countersunk slot, and cast iron frame and cover.

2.03 TRACER WIRE

A. Stranded copper AWG No. 10 with U.S.E. rated insulation. Color: Black.

B. Reflective Warning Tape.

2.04 SEWAGE EJECTOR

A. Provide in accordance with applicable requirements of Section 22 14 29, Sump Pumps.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Verify that trench cut excavation base is ready to receive work and that excavations, dimensions, and elevations are as indicated.

3.02 PREPARATION

A. Excavations shall be free of water and extraneous material immediately before sanitary sewerage products are installed or placed. Bottoms of trenches shall have a 6 inch sand bed and shall be formed to support the bottom quadrant of the pipe and fittings. Should rock be encountered or should bedding material be unsuitable to support the products at design elevation, continue excavation to an elevation 8 inches below the design elevation and backfill with clean sand.

B. Hand trim excavations to required elevation.

C. Remove large stones or other hard matter that could damage pipe or impede consistent backfilling and compacting operations.

D. Interior of pipe, pipe fittings, valves, drains, and cleanouts shall be cleaned of foreign substances before installation.

3.03 INSTALLATION REQUIREMENTS

A. Excavate pipe trench in accordance with Section 33 05 28, Trenching and Backfilling for Utilities. Hand-trim bottom of trench to approximately 6 inches below invert of pipe.

B. Top of pipe to finished grade shall be 36 inches unless otherwise indicated or approved by the Engineer.

C. Minimum depth from top of pipe to subgrade shall be 18 inches without concrete cap, unless otherwise approved by the Engineer.

D. Place bedding material meeting the requirements of Section 33 05 28, Trenching and Backfilling for Utilities, at trench bottom, level in one continuous layer not exceeding 8 inches in compacted depth. Compact bedding to 95 percent relative density.

E. Backfill around sides and to 6 inches above pipe with cover fill tamped in place and compacted to 95 percent relative density.

F. Test pipe distribution system and place tracer wire on top of pipe as specified herein prior to covering pipe. Backfill trench in accordance with Section 33 05 28, Trenching and Backfilling for Utilities.

G. Maintain optimum moisture content of bedding material to attain required compaction density.

H. Install products where indicated. Remove and reinstall products that are disturbed after installation. Ends of products to which future connections will be made shall be either valved, or properly plugged, capped, and anchored.

I. Connections to existing facilities shall be made with fittings and short bends to suit the actual conditions. Connect products in accordance with the product manufacturer's installation instructions.

J. Pipe and fittings shall be set to line and grade before joints are made up. Angular deflections of joints shall not exceed the recommendations of the pipe and fitting manufacturer. Should the alignment require deflection of joints to be in excess of those recommended, use special bends to achieve the indicated deflection. Pipe ends and joints shall be prepared in accordance with the manufacturer's recommendations. As a minimum, pipe ends shall be sanded and cleaned, fittings shall be cleaned, and solvent shall be applied to both pipe and fittings.

K. Install pipe, fittings, and accessories in accordance with ASTM D2321 and the manufacturer's instructions. Seal joints water tight.

L. Lay pipe to slope gradients as indicated.

3.04 INSTALLING PIPE

A. Protect pipe and fittings during handling to prevent damage.

B. Place, shape, and compact bedding material to receive barrel of pipe.

C. Start laying pipe at the lowest point; lay true to line and grade indicated.

D. Install pipe to bear on bedding material along its entire length.

E. Do not place the pipe on blocking material of any type.

F. Do not use wedges while installing the pipe.

G. Install pipe so that bells and grooves are on the upstream end.

H. Align each section of pipe with adjoining section leaving a uniform annular space between the bell and spigot to prevent sudden offsets in flow line.

I. As each section of pipe is laid, place sufficient bedding and backfill to hold it firmly in place.

J. Apply lubricant to rubber gasket (O-rings) immediately before joining pipe sections.

K. Keep interior of sewer clean as work progresses. Where small pipe sizes make cleaning difficult, keep a suitable swab and pulling line in the pipe, and pull through each joint immediately after jointing is completed.

L. Keep trenches and excavations dry and free of water during construction and until backfilling and compaction are completed.

M. When work is not in progress, securely plug ends of pipe and fittings to prevent extraneous matter from entering pipes and fittings.

N. Cut pipe ends, which project into a sewer structure, flush with the inside face of the structure and cover exposed pipe reinforcement with grout.

O. Where length of stub is not indicated, install a 4 foot length, and seal the free end with brick masonry bulkhead or an approved stopper.

P. Obtain the Engineer’s approval before covering pipe.

Q. Where indicated, place additional bedding material around and over the pipe in lifts not exceeding 6 inches before compaction. Compact each lift before placement of the next lift.

R. Accomplish compaction by methods that will avoid damage to pipe and will not disturb its alignment and grade. The use of vibratory rollers is prohibited until compacted cover over pipe has reached 3 feet or half the pipe diameter; whichever is greater.

S. Connect sanitary sewerage system to existing public sanitary sewers in accordance with requirements of the jurisdictional authority.

3.05 PIPE CLEANOUTS

A. Installation: Cleanouts shall be the same size as the pipe, with 4 inch diameter as a minimum. Cleanouts for drainage pipe shall consist of a longsweep 1/4 bend, or one or two 1/8 bends extended to the location indicated. Wall or accessible piping cleanouts shall be T-pattern, 90 degree branch drainage fittings having screw plugs.

Cleanouts shall be provided at the base of each riser and shall consist of a wye pattern fitting with a screw plug.

B. Form and place cast-in-place concrete pad with provision for sanitary sewer pipe ends.

C. Establish elevations and invert for inlets and outlets.

D. Mount cleanout surface hub level in grout to elevation indicated.

3.06 TRACER WIRE

A. Tracer Wire: Install tracer wire with reflective warning tape. Wire shall be accessible for tracing at all cleanout locations.

3.07 FIELD QUALITY CONTROL

A. Requirements:

1. Refer to Section 01 45 00, Quality Control, for field inspection and testing requirements.

2. Where drainage piping is located below invert slabs, conduct a ball, shuttlecock, or mandrel test to ensure that the line is free of obstructions subsequent to the placing of pervious backfill material over the line and prior to the placement of the concrete invert slab.

3. Upon completion of the test and determination that the line is free of obstructions, plug, cap, or otherwise close the open end or ends of the installed piping to prevent the entrance of debris into the lines.

4. Immediately prior to final inspection of the work, remove debris from manholes, drain inlets, and floor scupper drains. In the presence of the jurisdictional sanitary utility owner’s representative, prove by one of the methods specified above that the piping is free of obstructions.

5. The Contractor shall be responsible for making all necessary arrangements with the jurisdictional sanitary utility owner for performing and witnessing the required tests.

6. Request inspection of exposed piping prior to placing backfill.

7. Compaction testing of related earthwork shall be performed in accordance with applicable requirements of Section 31 00 00, Earthwork.

8. If tests indicate work does not meet requirements, remove such work, replace, and retest at no additional cost to the District.

B. Sanitary Pipeline Tests:

1. Perform air tests on all installed sanitary sewer pipes upon completion of backfill.

2. Hydrostatically test all installed sanitary sewer force mains.

3. Test all manholes for infiltration or exfiltration.

4. Test pipe sections by the exfiltration test.

5. Test sewer 24 inches or less in diameter with low pressure.

6. Sewers with a diameter greater than 24 inches may be tested by visual inspection.

C. Exfiltration Test:

1. Tightly plug end of pipe at downstream manhole.

2. Fill sewer, at either upstream manhole or standpipe, with water.

3. Allow water to stand for not less than eight hours, and until pipe has become saturated. Refill manhole or pipe to measuring mark, and begin test.

4. Exfiltration will be determined as follows:

   a. If standpipe has been filled, maintain a head of water not less than 2 feet nor more than 15 feet above highest point in the line being tested.

      - Exfiltration: that volume of water added to standpipe during a 20 hour period.

   b. If upstream manhole has been filled, measure original water elevation and, after 20 hours, final water elevation. Convert difference in elevation to gallons. Head of water shall be not less than 2 feet above highest point in the line being tested or not less than 2 feet above existing groundwater table, whichever is greater.

      - Exfiltration: that volume of water calculated from the difference in elevations during a 20 hour period.

5. Allowable leakage:

   a. Not more than 200 gallons per 24 hours per diameter inch per mile of sewer.

   b. If leakage exceeds permissible loss, sewer section will not be accepted.

   c. Do not conduct another exfiltration test until conditions of groundwater surrounding pipe return to a condition similar to those existing at beginning of test period.

D. Infiltration Test:

1. Tightly plug end of pipe at upstream manhole.

2. Install a 90 degree notch weir in downstream manhole.

3. Allow water to accumulate behind weir until overflow is constant.

4. Allowable leakage:

   a. Not more than 200 gallons per 24 hours per diameter inch per mile of sewer.

   b. If measured infiltration is more than the allowable rate, sewer section will not be accepted.

E. Low-Pressure Air Test:

1. Clean and set sections of pipe to be tested before starting air test.

2. Plug pipe outlets with pneumatic plugs capable of resisting internal testing pressures without requiring external bracing.

3. Immediately following pipe cleaning and wetting, slowly supply air to plugged pipe until internal air pressure reaches 4 psi. Allow at least two minutes for temperature to stabilize before proceeding, except slowly add air to maintain a 3.5 psig to 4 psig pressure. While temperature is stabilizing, spray plugs, pipes, and hoses with soap solution and eliminate air leaks.

4. After temperature has stabilized, measure time required for pressure to drop from 3.5 psig to 2.5 psig. If measured time exceeds allowable time, pipe will not be accepted.

5. Time, in seconds, for pressure to drop from 3.5 to 2.5 psig shall be not less than the following; time for intermediate lengths shall be interpolated:

Length of Pipe (Ft)	**Pipe Diameter In Inches**						
	8	**10**	**12**	**15**	**18**	**21**	**24**
25	18	28	40	62	89	121	158
50	35	55	79	126	178	243	317
75	53	83	119	186	267	364	475
100	70	110	158	248	356	485	634
125	83	138	198	309	444	595	680
150	100	165	238	375	510	595	680
175	123	193	277	425	510	595	680
200	141	220	317	425	510	595	680
225	158	248	340	425	510	595	680
250	176	275	340	425	510	595	680
275	194	283	340	425	510	595	680
300	211	283	340	425	510	595	680
350	227	283	340	425	510	595	680
400	227	283	340	425	510	595	680

F. Visual Test Method: Slowly pull a television camera through sewer and inspect for visual leaks and cracks in pipe. Repair leaks, then re-inspect pipe.

G. Joint Pressure Testing:

1. Insert sealing packer with joint testing capability, into sewer line.

2. Place sealing packer around joint and pressure test joint. If a drop in air pressure occurs, reseal the joint.

3. Repeat procedure for each joint.

H. Criteria for Acceptance: The section of sewer being tested will not be accepted if test results exceed allowable leakage or take less time than minimum holding time. If pipe proves to be unacceptable, immediately repair defective materials and installation. The Contractor will not be permitted to change to another test if original test method reveals system has failed.

I. Obstruction Tests:

1. Perform field tests to verify that installed sanitary systems are free from obstructions.

2. Remove obstructions by excavating at the apparent obstruction and repairing or replacing the defective pipe.

END OF SECTION 33 31 00

SECTION 33 40 00

STORM DRAINAGE UTILITIES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Storm Drainage Material

B. Excavation and Bedding

C. Laying Pipe

D. Pipe Joint

E. Backfilling

F. Concrete Encasement

1.02 RELATED SECTIONS

A. Trenching and backfilling for pipelines are specified in Section 33 05 28, Trenching and Backfilling for Utilities.

B. Catch basins, curb and gutter inlets, and manholes are specified in Section 33 05 16, Utility Structures.

C. Subsurface drainage system is specified in Section 33 46 00, Subdrainage.

D. Drainage systems for structures and trackway are specified in Section 22 14 01, Storm Drainage.

1.03 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for the site drainage system will be either by the lump-sum method or by the unit-price method as determined by the listing of the bid item for the site drainage system indicated in the Bid Schedule of the Bid Form.

B. Lump Sum: If the Bid Schedule indicates a lump sum for the site drainage system, the lump-sum method of measurement and payment will be in accordance with Section 01 20 00, Price and Payment Procedures, Article 1.02 Lump-Sum Measurement.

C. Unit Price: If the Bid Schedule indicates a unit price for the site drainage system, the unit-price method of measurement and payment will be as follows:

1. Measurement:

a. Pipe will be measured for payment by the linear foot for each type and size, along the center line of the pipe, installed complete in place.

b. Trench excavation, bedding for pipe, backfill, pipe fittings and joints, concrete for pipe encasement, cradles, culverts, and incidentals will not be measured separately for payment, and all costs in connection therewith will be considered as included in the linear foot measurement for pipe.

c. Catch basins, manholes, and other utility structures will be measured separately for payment as specified in Section 33 05 16, Utility Structures.

d. Concrete for headwalls and ditch closures will be measured by the cubic yard as specified in Section 03 30 00, Cast-in-Place Concrete. Reinforcing steel for headwalls and ditch closures will be measured separately for payment as specified in Section 03 20 00, Concrete Reinforcing.

e. Concrete for ditch lining will be measured by the linear foot for each type and width of ditch, along the centerline of the ditch. Reinforcing steel for ditch lining will not be measured separately for payment, but will be included in the linear foot measurement for ditch lining.

2. Payment: Site drainage system will be paid for at the indicated Contract unit prices for the computed quantities as determined by the measurement method specified in Article 1.03.C.1.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM C76 Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe

2. ASTM C270 Standard Specification for Mortar for Unit Masonry

3. ASTM C443 Standard Specification for Joints-Concrete Pipe and Manholes, Using Rubber Gaskets

4. ASTM C881 Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete

5. ASTM D2412 Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading

6. ASTM D2665 Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems

7. ASTM D2665 Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings

B. California Code of Regulations, Title 24, Part 2, California Building Code, Chapter 21 and Chapter 21A, Masonry.

C. AASHTO M-294 Standard Specification for Corrugated Polyethylene Pipe, 300 to 1500mm (12 to 60-inch) Diameter

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit detailed drawings that indicate site drainage in plan and section, including relationship to other systems, interfaces, and drainage structures, connections, alignment, grade, bedding and backfill, and other pertinent data.

C. Product Data: Submit manufacturers' product data for pipe and pipe connection materials.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Pipe Connection Requirements: Ends of pipe shall be bell-and-spigot, grooved, shiplapped, or secured with couplings, collars, or other connection fittings to assure continuous alignment of pipe and leakproof joints.

B. Concrete Pipe:

1. Reinforced Pipe: ASTM C76, Class III.

2. Joints and Gaskets: ASTM C443.

C. Plastic Pipe:

1. Pipe: PVC pipe conforming to ASTM D2665, SDR 26 or thicker, Type 1, Grade 1.

2. Cement: ASTM D2564.

D. High Density Polyethylene (HDPE) Pipe:

1. Pipe: AASHTO Specifications M-294, Minimum pipe stiffness at 5 percent per ASTM D-2412.

2. HDPE storm pipe shall have an outer corrugation with a smooth interior. Mannings "n" factor for the interior of pipe shall be a minimum of 0.012.

3. Joints: Pipe shall be joined with bell and spigot joint. And shall provide a minimum pull apart strength of 400 pounds. The bell shall be an integral part of pipe. Gaskets shall be installed in the bell by the pipe manufacturer.

E. Bonding Adhesive: Adhesive for bonding of mortar to concrete pipe and catch-basin and manhole openings shall be an epoxy-based bonding agent conforming to ASTM C881/C881m, Type V, tinted to show by visual inspection where it has been applied.

F. Bedding and Backfill Material: Refer to Section 33 05 28, Trenching and Backfilling for Utilities, for requirements.

G. Tracer Wire: Stranded copper AWG No. 10 with U.S.E. rated insulation. Color: Black. Tracer wire shall be installed on all buried non-metallic pipes. Refer to drawing MS13 for standard installation.

2.02 MORTAR

A. Mortar for catch-basin openings, and other locations where indicated shall be Type S mortar in accordance with Chapter 21 of the California Building Code, with a minimum compressive strength at 28 days of 1,800 psi.

B. Mortar shall be job mixed in accordance with requirements of ASTM C270, including measurement, mixing, proportioning, and water retention.

C. Accurately measure mortar ingredients and mix a minimum of three minutes after water has been added, in a mechanical batch mixer, using sufficient water to produce a workable and plastic consistency. Hand mixing will be permitted for small quantities only.

D. Use mortar within 90 minutes after mixing. Discard mortar that has been mixed longer or that has begun to set. If necessary, mortar may be re-tempered within this time limit, by replacing water lost due to evaporation and by thorough remixing.

2.03 CONCRETE

A. Concrete for headwalls, ditch closures, and lining or paving of ditches shall conform with applicable requirements of Section 03 11 00, Concrete Forming, Section 03 20 00, Concrete Reinforcing, Section 03 15 00, Concrete Accessories, Section 03 30 00, Cast-in-Place Concrete, Section 03 05 15, Portland Cement Concrete, and Section 03 35 00, Concrete Finishing. Provide Class 3000 - 1 inch concrete unless otherwise indicated.

PART 3 – EXECUTION

3.01 INSTALLATION OF PIPE

A. Excavation and Bedding:

1. Excavate trenches as specified in Section 33 05 28, Trenching and Backfilling for Utilities.

2. Bedding: Provide bedding as specified in Section 33 05 28, Trenching and Backfilling for Utilities. Where pipe is to be encased in concrete, place concrete against undisturbed soil.

B. Laying Pipe:

1. Lay pipe to line and grade indicated. If pipe is of the bell-and-spigot type, lay bells in cross-cuts cut in trench. Lay pipe with the bell or grooved end uphill.

2. Place circular pipe having elliptical reinforcement with minor axis of the reinforcement in a vertical position.

3. Prevent dirt from getting into pipe joints.

4. Remove pipe that is cracked, checked, spalled, or damaged from the work.

5. Clean interior of pipe of cement, dirt, and extraneous matter as the work progresses.

C. Pipe Joints:

1. Pipe joints shall be made secure and watertight.

2. Employ appropriate equipment to draw the sections of the pipe tightly together.

3. Joint of PVC pipe shall be prepared with cement conforming to ASTM D2564.

4. Joint of concrete pipe shall be prepared using a rubber gasket conforming to ASTM C443. Lubricant shall be applied per manufacturer specifications.

5. Joint of HDPE pipe shall use a gasket to form a silt tight connection. Joints shall remain silt tight when subjected to a 1.5 degree axial misalignment.

D. Backfilling:

1. Piping shall not be covered with backfill material, until inspected, tested, and approved by the Engineer.

2. After pipe has been installed, inspected, and approved, place and compact backfill as specified in Section 33 05 28, Trenching and Backfilling for Utilities.

E. Concrete Encasement:

1. If pipe is indicated to be entirely or partly embedded in concrete, support and brace pipe in a manner that will prevent movement or displacement of pipe during testing and during placement and consolidation of concrete.

2. Place concrete as specified in Section 03 30 00, Cast-in-Place Concrete, being careful to consolidate concrete under and around pipe without displacing pipe.

3. Provide minimum Class 3000 concrete as specified in Section 03 05 15, Portland Cement Concrete.

F. Tracer Wire:

1. Install tracer wire a minimum 6 inches above top of pipe. Cover with reflective warning tape per local requirements. Wire shall be accessible for tracing at all cleanout locations.

3.02 CONCRETE

A. Provide and place concrete reinforcement and concrete as indicated and in accordance with Section 03 20 00, Concrete Reinforcing, and Section 03 30 00, Cast-in-Place Concrete. Provide headwalls and ditch closures with “smooth form finish” and ditch lining with “floated finish” in accordance with Section 03 35 00, Concrete Finishing.

3.03 SEPARATION OF DRAINAGE

A. Trackway drainage, including underdrains, shall be separated from other drainage systems prior to discharge into the main storm drain system. Roof drains, floor drains, and other drainage systems shall discharge separately into the main storm drain system.

END OF SECTION 33 40 00

SECTION 33 46 00

SUBDRAINAGE

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Pipe and Fittings

B. Drainage Material

1.02 RELATED SECTIONS

A. Structure excavation and backfill are specified in Section 31 00 00, Earthwork.

B. Trenching and backfilling for pipelines are specified in Section 33 05 28, Trenching and Backfilling for Utilities.

C. Site drainage and surface run-off collection system are specified in Section 33 40 00, Storm Drainage Utilities.

1.03 MEASUREMENT AND PAYMENT

A. General

1. Subsurface Drainage System at Concrete Walls and Foundations: Measurement and payment for subsurface drainage systems, installed complete in place, will be by the lump-sum method as determined by the listing of the bid item for subsurface drainage systems indicated in the Bid Schedule of the Bid Form.

2. Composite Underdrains Along Trackway: Measurement and payment for composite underdrains, installed complete in place, will be either by the lump-sum method or by the unit price method as determined by the listing of the bid item for composite underdrains indicated in the Bid Schedule of the Bid Form.

3. Measurement: Excavating, trenching, and backfilling, filter aggregate, asphalt-treated permeable material, filter fabric, pipe fittings and joints, risers and cleanouts, preformed permeable drainage liner, and related fasteners and accessories will not be measured separately for payment, and all costs connected therewith will be considered as included in the lump-sum measurement for subsurface drainage systems and the lump-sum or unit-price measurement for composite underdrains.

B. Lump Sum: If the Bid Schedule indicates a lump sum for subsurface drainage systems and composite underdrains, the lump-sum method of measurement and payment will be in accordance with Section 01 20 00, Price and Payment Procedures, Article 1.02 Lump-Sum Measurement.

C. Unit Price: If the Bid Schedule indicates a unit price for composite underdrains along trackways, the unit-price method of measurement and payment will be as follows:

1. Measurement: Composite underdrains along trackways will be measured for payment by the linear foot, along the centerline of the pipe, installed complete in place.

2. Payment: Composite underdrains along trackways will be paid for at the indicated Contract unit price for the computed quantities as determined by the measurement method specified in Article 1.03.C.1.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM C14 Standard Specification for Nonreinforced Concrete Sewer, Storm Drain, and Culvert Pipe

2. ASTM C76 Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe

3. ASTM C425 Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings

4. ASTM C443 Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets

5. ASTM C444 Standard Specification for Perforated Concrete Pipe

6. ASTM C654 Standard Specification for Porous Concrete Pipe

7. ASTM D1593 Standard Specification for Nonrigid Vinyl Chloride Plastic Film and Sheeting

8. ASTM D2564 Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems

9. ASTM D2665 Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings

10. ASTM D2729 Standard Specification for Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings

11. ASTM F758 Standard Specification for Smooth-Wall Poly (Vinyl Chloride) (PVC) Plastic Underdrain Systems for Highway, Airport, and Similar Drainage

B. State of California, Department of Transportation (Caltrans), Standard Specifications:

- Section 29 Treated Permeable Bases
- Section 96 Geosynthetics

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit detailed drawings that indicate subsurface drainage in plan and section, including relationship to other systems, interfaces, connections, alignment, grade, bedding, drainage and filter aggregates, and other pertinent data.

C. Product Data: Submit manufacturers' product data for pipe, pipe connection materials, permeable drainage liner for foundation walls and retaining walls, filter fabric (geotextiles), and impermeable sheet liner.

PART 2 – PRODUCTS

2.01 PIPE AND FITTINGS

A. Pipe Connection Requirements: Ends of pipe shall be bell-and-spigot, grooved, shiplapped, or secured with couplings, collars, or other connection fittings to assure continuous alignment of pipe.

B. Concrete Pipe:

1. Plain Pipe: ASTM C14, Class 3.
2. Reinforced Pipe: ASTM C76, Class III.
3. Perforated Pipe: ASTM C444, Type I perforations, and conforming to ASTM C14, Class 3.
4. Porous Pipe: ASTM C654.
5. Joints and Gaskets: ASTM C443.

C. Plastic Pipe:

1. Pipe:
   a. PVC Pipe, Perforated: ASTM F758. Holes for all pipe sizes shall be 3/8-inch size. Perforated 6-inch diameter pipe may be ASTM D2729 or ASTM F758.
   b. PVC Pipe, Solid Wall: ASTM D2665, ASTM D2729, or ASTM F758, as applicable.
2. Cement: ASTM D2564.

2.02 DRAINAGE MATERIALS

A. Drainage and Filter Aggregates: Aggregate drainage and filter material (permeable material) for filling trenches under, around, and over underdrains, behind foundation and retaining walls, and for pervious blankets shall consist of clean, coarse sand and gravel or crushed stone, conforming to the following grading requirements:

Sieve Size	Percentage Passing Sieve
1 inch	100
3/4 inch	70-100
3/8 inch	40-100
No. 4	25-55
No. 10	0-40
No. 200	0-5

B. Asphalt Treated Permeable Material: Provide asphalt treated permeable base conforming with Caltrans Standard Specifications, Section 29.

C. Filter Fabric: Geotextile engineering fabric conforming to the Caltrans Standard Specifications, Section 96 Geosynthetics, for Filter Fabric for Underdrains.

D. Preformed Permeable Drainage Liner: Prefabricated composite plastic drainage panels designed to provide hydrostatic relief for concrete foundation walls and retaining walls as indicated. Panels shall be a button-pattern or other raised dimple feature which forms a drain core with flow channels at least 3/8 inch in thickness or clear depth, with geotextile filter fabric bonded to the raised pattern to prevent soil from entering the core channels and blocking the flow of water. Furnish drainage liner complete with installation accessories.

1. Drainage Matting: Hydrostatic-relief drainage liner may be a composite drainage matting, consisting of a nylon or polypropylene core geomatrix of open, three-dimensional design, with a geotextile filter fabric bonded to the core to prevent soil from entering the core and blocking the flow of water. Minimum thickness or clear depth shall be 1/2 inch. Furnish drainage matting complete with installation accessories.

E. Impermeable Sheet Liner: Flexible membrane sheeting, polyvinyl chloride conforming to ASTM D1593, minimum 10 mils thick.

1. Adhesive: Synthetic rubber base cement, manufactured for use with polyvinyl chloride or synthetic rubber membrane material for cold application.

2. Tape: Tape for sealing of laps and joints shall be a pressure-sensitive neoprene or vinyl-chloride rubber adhesive tape as recommended by the manufacturer of the sheet liner material or a heavy-duty cloth masking tape, minimum 3 inches wide.

PART 3 – EXECUTION

3.01 INSTALLATION OF PIPE

A. Excavate trenches for underdrain pipe as indicated. When not indicated, excavate to a width equal to the outside diameter of the pipe plus 12 inches and to a depth of 2 inches minimum below the grade established for the invert of the pipe. Coordinate with Section 31 00 00, Earthwork, and Section 33 05 28, Trenching and Backfilling for Utilities, as applicable.

B. Lay impermeable sheet liner over prepared and compacted sub grade where indicated. Lap edges not less than four inches and ends not less than six inches, with all laps sealed continuously with adhesive and tape. Repair punctures and tears in liner sheets that occur during subsequent construction operations.

C. Lay pipe to line and grade indicated. If pipe is of the bell-and-spigot type, lay bells in crosscuts cut in trench. Lay pipe with bell end uphill.

D. Fill space below the pipe invert with a layer of drainage aggregate as indicated, upon which the pipe shall be laid with perforations down. Sections shall be joined with sleeve couplings furnished by the pipe manufacturer or other appropriate method as determined by the pipe-ends configuration and approved by the Engineer. Employ appropriate equipment to draw pipe sections together.

E. Rocks, bricks, broken concrete or asphalt shall not be used to give intermediate support to pipes. Large stones or other hard objects shall not be left in contact with the pipes.

F. Fill excavations for underdrains with drainage or filter aggregates as indicated. Place drainage aggregate and compact as required to fill voids and prevent settlement, without damaging the underdrain pipe.

3.02 COMPOSITE UNDERDRAINS

A. Construct composite underdrains as indicated. Surround perforated pipe with filter aggregates and envelope the composite underdrain with filter fabric as indicated. Provide solid-wall PVC pipe risers and cleanouts, including installation accessories, as indicated.

3.03 INSTALLATION OF PERMEABLE DRAINAGE LINER

A. Apply preformed permeable drainage liner or drainage matting to below-grade concrete walls as indicated. Apply panels in accordance with the manufacturer’s instructions, with filter fabric side out.

B. Shingle each course, overlapping panels in the direction of water flow. Provide side laps in accordance with manufacturer’s instructions.

C. Provide interface with subsurface drainage piping at footings where indicated. Follow manufacturer’s instructions for correct interface installation.

END OF SECTION 33 46 00

SECTION 33 73 10

HIGH VOLTAGE POWER TRANSFORMER

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Requirements for designing, manufacturing, testing, delivering high voltage transformers to the Jobsite.

B. Installing and field testing: 230/34.5, 115/34.5 or 60/34.5 kV, three-phase, liquid-immersed high voltage power transformer units; for outdoor installation at the high voltage substation (HVSS) specified per the contract document, for specified location.

1.02 RELATED SECTIONS

A. Refer to the following Sections for requirements:

1. Section 01 33 00Submittal Procedures
2. Section 01 33 23Shop Drawings, Product Data, and Samples
3. Section 01 43 00Quality Assurance
4. Section 01 45 00Quality Control
5. Section 01 45 24Testing Program Requirements
6. Section 01 78 23Operations and Maintenance Data
7. Section 01 78 44Spare Parts and Maintenance Materials
8. Section 01 78 39Project Record Documents
9. Section 01 79 00 Demonstration and Training
10. Section 26 05 24Low Voltage Wires and Cables
11. Section 34 21 50Common Materials and Methods for Traction Power
12. Section 34 21 60Grounding and Bonding for Traction Power Facilities

1.03 MEASUREMENT AND PAYMENT

A. Measurement: Power transformers will be measured for payment per individual unit that is tested and furnished in accordance with the Contract documents.

B. Payment: Power transformers shall be paid for the Contract unit price per each individual unit of each type as indicated in the Bid Schedule of the Bid Form.

C. Spare parts shall be paid for in accordance with the requirements of Contract Specifications Section 01 78 44 Spare Parts and Maintenance Materials.

1.04 REFERENCES STANDARDS

A. Work shall be in accordance with following codes, standards, and specifications except as provided otherwise herein. Where requirements conflict with requirements specified herein the more restrictive requirements shall apply.

B. American Society for Testing and Materials (ASTM):

1. ASTM D877 Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disc Electrodes

2. ASTM D923 Standard Practice for Sampling Electrical Insulating Liquids

3. ASTM D971 Standard Test Method for Interfacial Tension of Oil Against Water by the Ring

4. ASTM D974 Standard Test Method for Acid and Base Member by Color Indicator Tile Action

5. ASTM D1298 Standard Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Conde, Petroleum and LiquidPetroleum Products by Hydrometer Method.

6. ASTM D1500 Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale)

7. ASTM D1524 Standard Test Method for Visual Examination of Used Electrical Insulting Oils of Petroleum Origin in the Field

8. ASTM D1816 Test Method for Dielectric Breakdown Voltage of Insulating Oil of Petroleum Origin Using VDE electrodes.

9. ASTM D3612 Standard Test Method for Analysis of Gases Dissolved in Electrical Insulating Oil Gas Chromatography

10. ASTM D6386 Practice for Preparation of Zinc (Hot-Dip) Galvanized Coated Iron and Steel Product and Hardware Surfaces for Paintingand

11. ASTM D7803 Practice for Preparation of Zinc (Hot-Dip) Galvanized Coated Iron and Steel Product and Hardware Surfaces for Painting

C. Institute of Electrical and Electronics Engineers Inc. (IEEE):

1. IEEE C37.2 Electric Power System Device Function Numbers and Contact Designations

2. IEEE C57.12.90 Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers and Guide for Short-Circuit Testingof Distribution and Power Transformers

3. IEEE 57.12.00 General Requirements for Liquid-Immersed Distribution,Power and Regulating Transformers

4. IEEE C57.13 Standard Requirements for Instrument Transformers

5. IEEE C57.19.01 Performance Characteristics and Dimensions for Outdoor Apparatus Bushings

6. IEEE C57.104 Guide for Interpretation of Gases Generated in Oil-Immersed Transformer

7. IEEE C62.11 Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits

8. IEEE 693 Recommended Practice for Seismic Designs of Substations

D. European Union:

1. EU 548/2014 Ecodesign – Power Transformers

E. National Electrical Manufacturers Association:

1. NEMA TR1 Transformers, Step Voltage Regulators and Reactors.

2. NEMA WC 70/ ICEA S-95-658 Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy

F. National Fire Protection Agency (NFPA):

1. NFPA 70National Electrical Code (NEC)

1.05 ABBREVIATIONS AND DEFINITIONS

A. AC Alternating Current

B. BIL Basic Impulse Level

C. C Celsius

D. CT Current Transformer

E. DC Direct Current

F. DbA Decibels

G. GFI Ground Fault Interrupter

H.	HV	High Voltage
I.	Hz	Hertz
J.	KCMil	Thousand Circular Mils
K.	KV	Kilovolts
L.	L-G	Line to Ground
M.	LTC	Load Tap Charger
N.	LV	Low Voltage
O.	MCOV	Maximum Continuous Operating Voltage
P.	MVA	Mega Volt-Amperes
Q.	NC	Normally Closed
R.	NO	Normally Open
S.	NPT	National Pipe Thread
T.	SCADA	Supervisory Control and Data Acquisition
U.	TOV	Temporary Overvoltage
V.	V	Volts, Voltage

1.06 SUBMITTALS

A. General: Refer to Contract Specifications Section 01 33 00, Submittal Procedures, and Contract Specifications Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Provide design calculated values, Shop Drawings, data and other documentation as indicated below:

C. Product Data:

1. Transformer outline drawing
2. Transformer bushing drawing
3. Schematic and wiring diagrams
4. Bushing CT excitation and ratio correction factor curves; accuracy curves versus frequency (up to 50th harmonic)

5. Test results and reports for tests specified herein, including certified test reports for metering and relaying current transformers

6. Instruction manual

7. Details of terminal and ground connectors

8. Transformer resistance

9. Transformer impedance

10. Transformer test plans and detailed procedures including design and routine tests

11. Test equipment data and calibration certificates

12. Nameplate data, including weight and center of gravity

13. Hydraulic diagram including location of valves and joints

14. Transformer efficiency at 100 percent, 75 percent, 50 percent, and 25 percent of the full load rating

15. No load and full load losses for transformer efficiency analysis

16. Signature of transformer magnetizing inrush current indicating percentage of harmonic content. Factory test results of similar rated unit will suffice

17. Transportation impact recorder records

D. Operations and Maintenance Manuals: Provide a systems operations and maintenance manual in accordance with Contract Specifications Section 01 78 23, Operations and Maintenance Data. Standard off the shelf manuals for transformer components may be considered, subject to approval by the Engineer. One set of illustration manuals, and operating instructions manuals shall be shipped in a pocket inside the control cabinet door for each transformer.

E. Transport and delivery plan.

F. Supplier Qualifications.

G. Recommended Spare Parts List and Special Tools List.

H. Material Safety Data Sheets (MSDS).

I. Test Program Plan.

J. Factory Test Procedures.

K. Field Test Procedures.

L. Factory Test Reports.

M. Field Test Reports

1.07 SYSTEM DESCRIPTION

A. The power transformers will be used to transform utility power from 230, 115, or 60kV to 34.5kV AC power for distribution.

1.08 QUALITY ASSURANCE

A. Electrical components, devices, and accessories shall be listed and labeled in conformance with NFPA 70, Article 100.

B. Supplier Qualifications:

1. The manufacturer of the power transformers must have a minimum of five years manufacturing experience.

2. The Supplier's designer responsible for the design of the power transformers shall have a minimum five years of project proven design experience.

3. Power transformers shall be proven standard products, or equivalent to the standard products of manufacturers engaged in the production of such equipment for at least the past five years.

1.09 DELIVERY, STORAGE, AND HANDLING

A. Power transformer shipments shall be monitored by impact recorders. Impact recorders shall be 30-day dual motion devices, that shall be installed and securely sealed at the factory prior to shipment. These recorders shall be opened and inspected prior to unloading the transformer from the railcar or truck. Impact recordings shall be downloaded from the recorder in the presence of Engineer. Prior to unloading, pressure and dew point of the inert gas used in shipment shall be measured and recorded. Physical inspections and core ground tests shall be made.

B. Equipment shall be weatherproofed for shipment. Connection openings shall be closed to prevent entrance of foreign material during shipment and storage.

C. Equipment shall be handled and stored in conformance with manufacturer's instructions. One copy of these instructions shall be included with the equipment at time of shipment.

1.10 WARRANTY

A. A warranty for the power transformers and system components shall be provided and signed by the manufacturer and installer agreeing to correct system deficiencies and replace components that fail in materials or workmanship for a period commencing five years from the date of revenue service.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

A. Power transformers shall be manufactured by one of the following:

1. ABB Electric
2. Siemens
3. Virginia Transformer
4. Or Equal

2.02 RATINGS

A. The power transformer shall be rated as indicated, 230, 115, or 60 – 34.5Y/19.92 kV, three phase, 60 hertz, oil (natural ester) immersed ONAN/ONAF/ONAF cooled, outdoor type, 65 degrees Celsius, with 6.5 percent impedance at the normal MVA level indicated with plus or minus 7.5 percent tolerance.

B. MVA rating: 27/36/45 MVA

2.03 POWER TRANSFORMER ELECTRICAL CHARACTERISTICS

A. Voltage and Frequency:

1. Rated Primary Voltage:230 kV, 115 kV, or 60 kV
2. Rated Secondary Voltage:34.5 kV
3. Frequency: 60 Hz

B. Windings and Phase Connection:

1. Primary Winding Connection: Three phase, delta
2. Secondary Winding Connection: Three phase, wye solidly grounded

C. Noise Level:

1. The specified average noise levels when force air (FA) cooling fans are turned on shall be in accordance with NEMA, TR 1 Table 1 requirements.

D. System Voltage and their Basic Insulation Level (BIL):

1. System Voltage; kV rms			
Maximum System HV	242 kV	121 kV	72.5 kV
System Nominal Operating Voltage HV	230 kV	115 kV	60 kV
Operating Voltage LV	34.5 kV	34.5 kV	34.5 kV
Nominal Tap	230 kV: 34.5 kV	115 kV: 34.5kV	60 kV: 34.5 kV

2. Basic Insulation Level (BIL 1.2/50 microseconds); kV –Peak			
HV Winding	900 kV	550 kV	350 kV
HV Bushing	900 kV	550 kV	350 kV
LV Winding and Bushing	200 kV (L-G)	200 kV (L-G)	200 kV (L-G)

E. Terminal Arrangements:

1. Terminal arrangements shall comply with IEEE C57.12.00.

2. High Voltage Side:

   a. Type: Bushing characteristics shall comply with IEEE C57.19.01. Bushings (3) shall be top mounted suitable for NEMA 4-hole, tinned copper terminal lug with NEMA Pad. The lightning arresters (3) shall be top mounted on the transformer high voltage side suitable for NEMA 4-hole tinned copper terminal lug and with NEMA Pad. The terminal lug shall have sufficient length to apply at least two crimps. A stranded copper conductor with proper size for the transformer load shall be crimped to the terminal lug with proper crimping tool, at its two ends, to connect the transformer bushings and the tubular bus. Adequate size of bolts and nuts shall be used to connect the terminal lugs, to the terminal pads of transformer brushings, the lightning arrestor bushings, and the tubular buses. A stranded copper conductor shall be tapped from the conductor that connects the transformer bushings and the tubular bus and connects to the lightning arrestors via NEMA 4-hole terminal lug. The conductor shall have the same size and type like the conductor that connects the transformer bushings and the tubular bus, and shall be tapped using a proper clamping hardware.

   b. Maximum Voltage:

Rating Voltage	230 kV	121	72. 5 kV
BIL	900 kV	550 kV	350 kV

3. Low Voltage Side:

    a. Type:

        1) Bushing characteristics shall comply with IEEE C57.19.01. Bushings(3) top mounted or side mounted, suitable for cables terminating are as indicated below.

    b. Maximum Voltage Rating:

        1) Power Bushings(3): 34.5 kV

        2) BIL (L-G): 200 kV peak

        3) Neutral Bushing (1): 25 kV rms

        4) Neutral Bushing BIL: 150 kV peak

F. Accessories:

1. The following accessories shall be provided for each transformer. Unless otherwise indicated, where device contacts are required, a minimum of two normally open contacts shall be furnished. Contacts shall be suitable for operation on 125 V DC alarm, and tripping circuits.

    a. Bottom drain valve and outlet for filter press connection 2 inches minimum size globe valve NPT female, with built-in 3/8 inch sampling valve. This valve shall be suitable for complete drainage of the tank. Valve shall not be located under radiator banks or be obstructed by other equipment.

    b. Top filter press connection valve, 1 inch minimum size, globe NPT female.

    c. 2 inch plugs for vacuum connection during vacuum filling, located remote from the top filter press connection.

    d. Top and bottom shut-off valves and drain valve, on conservator tank and each detachable radiator.

    e. Mechanical pressure-relief, device 363PR, automatic reseal type, with alarm contact suitable for 125 V DC.

    f. Magnetic liquid-level indicator, device 371QL, with a low-level alarm contact and low-low-level trip contact suitable for 125 V DC.

    g. An optional gas-sampling valve readily accessible from ground level.

    h. Top-oil temperature indicator device, 326QT, with maximum indicator and three high-temperature (alarm and trip) contacts suitable for 125 V DC.

    i. One hot-spot, four-stage winding-temperature relay, device 349WT, with contacts that upon increasing temperature shall sequentially perform the following functions:

        1) Energize first stage cooling equipment.

        2) Energize second stage of cooling equipment.

        3) Initiate alarm.

4) Initiate tripping.

2. The pickup point of each of the sets shall be adjustable and factory-set. The setpoint for each stage shall be independently adjustable, and each stage shall have two electrically independent, normally open contacts.

3. Sudden-pressure relay, device 363SP, with auxiliary seal in relay and reset pushbutton. The auxiliary relay shall have two (alarm and trip) electrically separate terminal contacts wired to the outgoing terminal blocks.

4. Transformers with an inert-gas-pressure, device 363GP, oil preservation system, shall be equipped with an externally mounted inert gas cylinder complete with a continuously monitoring type, combustible-gas analysis system, with indicating meter, alarm and trip contacts adjustable over the full range. Alarm and trip contacts shall be suitable for 125 V DC.

5. Surge Arresters: Metal Oxide Surge Arresters (Station Class):

   a. HV Side: (230 kV) Three – 192 kV rms, (152 kV rms MCOV)
      (115 kV) Three – 96 kV rms, (76 kV rms MCOV) (69 kV)
      Three – 60 kV rms, (48 kV rms MCOV)

   b. LV Side:(34.5 kV) Three – 30 kV rms, (24.4 kV rms MCOV)

6. HV surge arrestor ratings shall be confirmed based on the utility power system grounding configuration, engineering analysis of utility temporary overvoltage (TOV) magnitude and duration, surge arrestor TOV ratings, and equipment insulation coordination.

7. Two pads for attaching 250 kcmil ground cable to the tank with NEMA standard lugs, located at opposite corners of the tank.

8. Standard ANSI nameplate.

2.04 CONSTRUCTION DETAILS

A. Tank and Base:

1. The transformer tanks shall be of welded steel construction. The cover shall be bolted together with the tank walls through a special flange with stainless steel screws and nuts.

2. The transformer tanks shall be suitable for filling with oil under full vacuum. The design shall include recommendations for back-pressure during filling.

3. The transformer bases shall be chamfered to permit skidding or rolling in a direction parallel to either centerline, and the chamfer shall have a slope ratio of 1:4 so that rollers may be easily started. Unchamfered bases against embedded steel channels may be used as an alternative.

4. Pulling eyes shall be provided for pulling in four directions. The center of the eye shall be located not less than 8 inches above the base to permit the pulling shackles to clear the rollers on which the transformer is moved.

5. Enclosures shall be weatherproof and designed to prevent the accumulation of standing water along panel doors. Gaskets of doors shall be recessed and provided with mechanical gasket stops or shielded for adequate protection from the weather.

6. Oil-filling connections shall be provided with deflection plates inside the tank to prevent the force of incoming oil from impinging on the core and windings.

7. Transformers shall be provided with lifting lugs and jacking pads on four corners. Pads shall be located at least 22 inches above the base of the equipment. The jacking pad surface shall be at least 6 inches by 6 inches. The center of the jacking pad surface shall have at least 10 inches free clearance from the side of the tank and base. The areas near the jack pads or surface shall be kept clear of all radiators, fans, boxes, piping, and the like, to facilitate handling of jacks.

8. Lifting eyes shall be provided for the tank cover.

9. The centerlines of tank or base shall be permanently marked near the base on all four sides of the tank or case and shall be indicated on the Shop Drawings.

10. The shipping center-of-gravity shall be permanently and plainly marked “Shipping Center of Gravity” on four sides of the tank and base to aid in handling and shall be dimensioned on the Shop Drawing.

11. The gasketed surfaces around openings in the transformer tank and cover for such items as bushings, manholes, relief devices, and the like, shall be raised sufficiently to prevent the accumulation of water around the gasket. Gaskets in contact with oil-bearing surfaces shall be of nitrile rubber. Cork or Corprene (cork and neoprene material) gaskets shall not be accepted.

12. Base construction shall secure the core to prevent relative motion of the core and coil during shipment, handling, and seismic shock.

13. Base construction shall be provided with structural steel support beams, ready to be mounted on a concrete pad.

B. Bushings:

1. The bushing arrangement and terminal designation shall be standard. The bushings shall be furnished with four-hole NEMA pad terminals with cable/bus connectors.

2. Bushing current transformers shall have ratios as shown on the Contract Drawings, and shall conform to IEEE C57.13, with an accuracy of C-800 multi-ratio transformers for relaying and 0.3B2.0 single ratio transformers for metering. Short-time ratings shall be as follows:

a. Mechanical Short Time: 120 times rated secondary current.

b. One-Second Thermal: 35 times rated secondary current.

c. Continuous Thermal: Two times rated secondary current.

3. Bushings shall have electrical and mechanical characteristics suitable for the service voltages and loading specified. Where practicable, bushings shall be IEEE Standard transformer type.

a. High-voltage bushings shall be oil-filled with a capacitance tap outlet.

b. For low voltage bushing configuration, see Contract Drawings or Specification.

4. The high and low voltage bushings shall be treated with silicone type, Dow Corning Sylgard, Midsun 570 HVIC High Voltage Insulator Coating, or equal. Coating shall have a dielectric strength of 15 kV/4 mm in accordance with the requirements of ASTM D149, with an application temperature range of 0 degrees Fahrenheit to 120 degrees Fahrenheit. Apply the silicone coating to the bushings at the factory.

C. Surge Arresters: Surge arresters shall be single-phase, outdoor station class metal oxide type, pressure class 1, pedestal mounted, furnished complete with mounting and ground hardware, fabricated and factory tested in accordance with IEEE C62.11. Surge arrester insulators shall be colored light gray.

D. Connections: Bushings shall be mounted on the tank top or side, cable box configuration as indicated and shall have silver-plated studs. The cable box shall be rated NEMA 3R. The terminal arrangement shall be suitable for connections as indicated.

E. Core and Coils:

1. The core of each transformer shall be fabricated from the manufacturer's standard steel, grain oriented and laminations M2 (0.009 inches thickness) or M3 (0.011 inches thickness). The core shall be carefully assembled and rigidly clamped to ensure adequate mechanical strength and minimum vibration under all operating conditions.

2. The windings shall be of copper and have insulation of high dielectric and mechanical strength and shall be arranged to permit free circulation of oil. Proper internal barriers shall be provided. Additional insulation shall be provided on end coils to protect against line disturbances. The coils shall be shaped and braced to provide for expansion and contraction due to temperature changes and to avoid abrasion of insulation. The coils shall be braced to prevent distortion due to any abnormal operating conditions.

3. The core ground bushing connection shall be on the transformer tank top to facilitate testing of the core clamp insulation without opening the transformer tank. The bushing shall be connected by a removable ground strap to a ground pad on the tank top. The entire assembly shall be covered by a removable metal box. If the core ground bushing is not located within 20 inches of a manhole on the tank top, provide access a 9.5 inches handhole not further than 17 inches from the bushing.

F. Transformer Insulating Oil: The transformer manufacturer shall supply insulation oil via tanker trucks with oil filtration plant and vacuum filling. The transformers shall be filled with dry inert gas for shipment; and delivered to the designated storage area with gas filling only. The manufacturer shall submit the following items to ensure that the correct insulating oil is supplied, and the transformer tanks are filled as recommended:

1. Manufacturer's standard specifications for the transformer insulating oil, including requirements that the oil be free of polychlorinated biphenyls (PCB) and tested in accordance with ASTM D1816.

2. Instructions for oil storage, handling, and filling of the transformer tanks, including required quantities and procedures for filling at time of installation.

3. Additional copies of the manufacturer's standard specifications for the transformer insulating oil, and instructions for the handling of oil and filling of tanks, shall be included in the manufacturer's instruction manual specified herein.

G. Oil Preservation Equipment: The oil preservation system shall be an inert-gas pressure system or a conservator system in which oil is not in direct contact with the atmosphere. For the inert-gas protective system, the following provisions shall apply:

1. The transformer shall be provided with positive pressure, automatic, inert-gas protection, device 363GP, in the form of a cushion of nitrogen gas above the oil in the main tank and any auxiliary oil-filled tanks.

2. The gas control cabinet, which also shall house the nitrogen gas cylinder, shall be a separate weatherproof cabinet mounted vertically. The bottom of the cabinet shall be approximately one foot from the transformer base pad.

3. The gas system shall include purging and test valves, so arranged that an oxygen analyzer may be conveniently attached. The transformer tank supplied by the gas system shall have an outlet connection remotely located from the inlet connections to facilitate purging.

4. The gas pressure in the transformer tank shall be maintained at a positive value, at all times. Three NO alarm contacts suitable for 125 V DC shall be provided for signaling low and high transformer gas pressure and low cylinder pressure.

5. One U.S.A. standard bottle of nitrogen gas shall be furnished with the transformer, pressurized at the working pressure and complete with gauge.

H. Taps and Tap Changers:

1. The high-voltage winding shall have four no-load, full capacity taps: 5.0 and 2.5 percent above and 5.0 and 2.5 percent below the rated line-to-line voltage.

2. De-energized tap changing shall be accomplished by operation of a lockable handle brought out through the side of the case at a height that will facilitate ease of operation. Tap connections shall be clearly marked so that the tap selected is clearly identifiable. The design of tap changer shall make it impossible to short out sections of windings, or to select taps outside the prescribed range.

3. The tap position indicator shall be visible through a viewing window.

4. The tap changer shall have the ability to coordinate with a transformer operating in parallel.

5. An on-load tap changer (LTC) shall be provided in the low voltage winding. The LTC shall have a separate oil tank so the oil in contact with the winding cannot be contaminated with oil from the tap changer. Thirty-two equal steps 5/8 percent + neutral (33 positions) for automatic adjustment of the load voltage shall be provided. Regulation shall be plus or minus 10 percent with plus or minus 10 percent tolerance. The LTC shall be equipped with the following:

    a. LTC shall be reactive vacuum type, Rainhausen or equal.

    b. The LTC shall be designed to carry daily transformer overloads within the transformer normal life expectancy. The LTC shall be capable of carrying 130 percent rated tap nameplate current continuously.

    c. The LTC shall have necessary auxiliary equipment including current transformers necessary for proper operation and control.

    d. Undervoltage protection to prevent the LTC mechanism from going to maximum raise position on loss of feedback power.

    e. Alarm contacts to annunciate, locally and remotely, maximum raise and lower positions.

    f. Four contacts wired to permit raising and lowering of the tap changer for future BART SCADA systems.

    g. Field-adjustable in the 10-60 second range. The default set point for the LTC response time shall be set at 30 seconds.

    h. LTC shall be set to maintain a target voltage of 1.875 percent (3*5/8 percent) above the nominal on the 34.5 kV side or 35.147 kV.

    i. Other necessary control equipment to back-up the primary control equipment and to prevent excursions outside the set bandwidth.

    j. Local and automatic selector switch for the LTC shall be provided. Two contacts shall be provided for local and remote indications exclusively.

    k. Oil level gauge, device 371 LTC, with low level alarm contact suitable for 125V DC.

l. Pressure relief device, 363 LTC/PR, to operate LTC lockout device with two contacts for local and remote alarms.

m. Drain valve with sampler.

n. Dehydrating breather.

6. Auxiliary contacts for the above devices shall be rated 2 amperes at 125 V DC. Sufficient contacts for alarm, data logging and shutdown functions shall be provided in addition to the number of electrical independent contacts required for control circuitry. If standard supervisory devices do not have the number of contacts required for control indication, auxiliary relays may be used for contact multiplication. These relays shall be included and installed in the transformer control cabinet.

I. Efficiency

1. Transformers rated 10 to 40 MVA: Conform to EU 548/2014, Ecodesign – Power Transformer efficiency table below:

EU Ecodesign Transformer recommended Minimal Peak Efficiency Index (PEI) (See definition below)	
Transformer KVA	PEI
3150 < Sr ≤ 4000	99.532
12500	99.64
16000	99.663
20000	99.684
25000	99.7
31500	99.712
40000	99.724

For transformers with higher rating than 3150 kVA, use the peak efficiency Index (PEI). The methodology for calculating the PEI is based on the ratio of the transmitted apparent power of a transformer minus the electrical losses to the transmitted apparent power of the transformers:

$$\mathrm{PEI} = 1 - \frac{2(\mathrm{P_0} + \mathrm{P_{c0}})}{s_r \sqrt{\frac{\mathrm{P_0} + \mathrm{P_{c0}}}{\mathrm{P_k}}}}$$

$P_{0:}$ No load losses measured at rated voltage and rated frequency, on the rated tap.

$P_{c0:}$ Electrical power required by the cooling system for no load operation.

Pk: Measured load loss at rated current and rated frequency on the rated tap, corrected to the reference temperature.

Sr: Rated power of the transformer or autotransformer on which Pk is based.

J. Cooling Equipment:

1. Each transformer shall be equipped with a sufficient number of radiators to operate as a self-cooled, forced air cooled (first stage), forced air cooled (second stage) (ONAN/ONAF/ONAF) in accordance with the specified ratings as indicated.

2. The transformers shall be provided with radiators attached to the tank by bolted and gasketed flanges. Radiators of the same nominal dimensions shall be interchangeable. A lifting eye shall be provided on each radiator. Provisions shall be made to permit removal of the radiator without interfering with the operation of the transformer. An oil-tight blank flange shall be provided for each connection for use when the radiators are detached. A drain plug and vent plug shall be provided in each radiator header.

3. Cooling fan support shall be provided on the transformers in a manner which will permit easy removal of the fans for maintenance.

K. Cooling System Controls:

1. The manufacturer shall provide room for wiring route, control, and control cabinet.

L. Control, Auxiliary Power, Instrument and Alarm Wiring:

Control, auxiliary power and alarm circuits shall be completely wired to the control cabinet. Wring shall run in separate, galvanized rigid steel conduits. Wiring terminations shall be on molded-type terminal blocks with compression-type terminals and laminated dust covers suitable for engraving. Terminal blocks shall be the molded type. Terminal blocks shall have at least 20 percent spare positions. Gages may be connected to the conduit system with short lengths of insulated flexible cable. Dust covers and terminal blocks shall be included.

1. Terminations shall be segregated and separated into low-voltage power, low-voltage control and metering, and low-level signal circuits. Not more than two wires shall be connected to one terminal. Terminal blocks for interface connections between the external wiring and the equipment wiring shall be enclosed and located in areas with adequate space and clearances. These areas shall allow convenient placement and termination of the external cables in neat and orderly arrays. Future cable removal or additions shall not require temporary removal or disconnection of adjacent unrelated cables. The location and arrangement of terminal blocks for external wiring shall be subject to review and approval by District.

2. Wiring connections to CT taps shall extend from each current transformer to short-circuiting type terminal blocks, General Electric Type EB-27, or equal. Secondary wiring from CT’s shall be No.10 AWG stranded copper installed in a weatherproof conduit system.

3. Control and indication wiring shall be not smaller than No. 14 AWG. Control, instrument, and alarm circuits shall be shielded. Control wire shall be stranded copper conductor, Type XHHW, with 600 V insulation. Wiring shall be capable of passing the Flame-Resistant Test, NEMA WC 70 (ICEA S-95-658).

4. Wiring across hinges shall employ the use of No. 14 AWG, 41 strand, extra-flexible copper conductors. Hinge wiring shall be arranged so that any twisting shall take place in the longitudinal axis of the conductor, rather than across the conductor.

5. The control cabinet shall be NEMA Type 4X with doors located on either side of the transformer tank and within reach of person standing at the transformer base level. It shall contain all auxiliary devices except those thamust be located directly on each transformer. Doors shall be hinged and provided with stops to hold the doors in open position until released by the operator. Auxiliary panels shall be hinged or otherwise designed for ready access to relays, control devices and associated terminals for testing, adjustment, and maintenance.

6. Wiring and components shall be arranged so that instruments or devices may be removed and serviced without disturbing the wiring. No wire shall be routed across the face or rear of an instrument, junction box, or other device in a manner that prevents the opening of covers or obstruct access to leads, terminals, devices, or instruments.

7. The cabinet shall be provided with internal illumination and a 120V, 20 ampere AC outlet supplied from the 120V AC auxiliary power circuit. Outlet shall be GFI type.

8. Eposed wiring in the control cabinet shall be formed with wiring neatly grouped in bundles, using wiring cleats, or ties, and with groups substantially supported.

9. The insulation or jacket of each insulated conductor in multiconductor cables shall be color-coded for identification. Color coding shall be by actual color impregnation, not by printed wording or numbering.

10. Only ring tongue, compression-type connectors that firmly grip the conductors shall be used. The crimping tools used shall be approved by the terminal manufacturer. Soldered terminal block or connection are acceptable. The manufacturer’s standard terminal block or connection shall be supplied.

11. Locknuts or lock-washers shall be applied to stud type terminals. For screw-type terminals, a split type lock-washer shall be used between the terminal lug and screw head. The manufacturer’s standard terminal block or connection shall be supplied.

12. Metal raceway shall be provided for instruments requiring thermocouple or RTD connections in accordance with manufacturer’s standard practices.

13. Splices or parallel connections shall not be made in the transformer tank braces or in other non-accessible locations. Such connections shall be made at terminal blocks or readily accessible splice boxes.

14. Loss of control power to controller IOM or to 363SP relay shall issue a loss of communication and protection alarm and trip the 386-lockout relay.

M. Control and Alarm Voltages:

1. Annunciator and protection circuits shall conform to ANSI standards.

2. The LTC auxiliary power supply, including LTC motor supply, shall be 120/240 V, three-wire, single phase, 60 Hz. The LTC control and indicator circuit supply voltage shall be 125 V DC.

N. Auxiliary Power Supply: Each transformer shall be equipped to accept a 120/240 V, three-wire, single-phase 60 Hz power supply.

1. Thermostatically controlled space heaters shall be provided in a readily accessible location in the control cabinet and terminal chambers for the prevention of moisture condensation. Heaters shall be provided with protective screens. Space-heater circuits shall be provided with both a manual and thermostatically controlled switch. Each heater circuit shall be separately fused and coordinated to maintain selectivity with the main protective device. Space heaters shall be rated 240 V AC and sized for proper heat output when operated at 120 V AC.

2.05 FINISHES

A. Equipment shall be cleaned, primed, and finish painted in accordance with the manufacturer's standard specifications, suitable for outdoor service. A reasonable quantity of touch-up paint shall be provided. The color of the exterior finish paint shall be medium beige unless otherwise directed by the District. Interior control cabinet finish shall be the standard color provided by the manufacturer.

B. Cooling fins shall be hot dip galvanized, not painted per ASTM D6586 and D7803.

2.06 NAMEPLATES

A. Stainless-steel diagram nameplates shall be provided in accordance with ANSI standards. The nameplates shall bear the purchase order number and purchase order item number.

B. Each control device shall be provided with a suitable nameplate giving the device name plus the IEEE C37.2 device number. The nameplates shall be brass, stainless steel or laminated plastic with engraved letters.

C. Each device in the control cabinet shall be provided with an engraved laminated plastic or stainless-steel nameplate.

2.07 SPARE PARTS LIST

A. The manufacturer shall submit a recommended spare parts list and special tools list concurrent with the product data submittal. For detailed Spare Parts requirements, Refer to Contract Specifications Section 01 78 44, Spare Parts and Maintenance Materials.

2.08 SOURCE QUALITY CONTROL

A. General

Notification of Tests: The Engineer shall be notified not less than 30 Days in advance of dates scheduled for tests. Test procedures shall be approved by the Engineer prior to dates of scheduled tests.

1. Test Program Plan: Submit a plan identifying the approach to be used for accomplishing the required shop tests. The projected schedule for test and test execution, and submittal of test results shall be included.

2. Test Procedures: Shall include as a minimum:

    a. Objective and scope

    b. Test set up

    c. Test equipment to be used

    d. Personnel required for the test

    e. Estimated duration of test

    f. Pass/fail criteria

    g. Samples of data sheets to be used

    h. Test procedures shall be submitted not less than 45 Days prior to test for review and approval.

3. Test results will be reviewed and accepted by the Engineer as submitted. If additional tests are required, because submitted test results do not comply with the requirements of the specifications, retest shall be performed, at no additional cost to the District. The retesting shall be documented and submitted to the Engineer as part of the test report.

4. Test Reports: Test reports shall document the results obtained and be certified by the manufacturer. Reports shall include the following:

    a. Equipment tested, including model and serial numbers

    b. Title of test

    c. Objective of test and pass/fail criteria

    d. Summary and conclusions

e. Location and date of test

f. Test method and equipment used for test

g. Results, including calculations, curves, photographs, and other supporting data

h. Abbreviations and references

i. Signatures of test supervisor and witnesses

5. Test Witnessing: The District reserves the right to witness tests including factory tests conducted elsewhere by the Contractor, its Suppliers, or by an independent testing laboratory. If the District determines not to witness a test or tests, test reports shall still be submitted to the Engineer for review. Test reports shall be signed by all witnessing parties.

B. Test Equipment

1. Provide calibrated test equipment, instruments, tools, and other required items necessary to perform the tests indicated.

2. Replacement materials

a. Replace or repair equipment, parts, and materials that are rejected, damaged, lost, or consumed during performance of shop tests. Replacement materials shall be new and warranted.

C. Factory Tests

1. Factory testing shall be performed in accordance with the requirements of Contractor Specifications Section 01 45 24, Testing Program Requirements.

2. Factory tests shall include design and production tests performed by the Supplier, or a testing agency prior to shipment of the equipment. Unless otherwise indicated, District may waive the requirements for design tests upon review of test procedures, test results, or certified documentation of like equipment. Tests results on like equipment or materials shall be submitted for the design tests that are to be waived.

a. Design Tests: Design tests shall be performed by manufacturer on one transformer prior to series production. This transformer shall be subject to the design tests specified in Table 1.

b. Routine Tests: Routine tests as specified in Table 1, shall be performed by manufacturer on each transformer.

c. Test specified in Table 1 shall be performed in accordance with IEEE C57.12.90 unless otherwise specified herein.

TABLE 1: ROUTINE AND DESIGN TESTS OF TRANSFORMER

TESTS	Routine	Design
Resistance Measurements	X	
Ratio (Note 1)	X	
Polarity and Phase Relation	X	
No-Load Losses and Excitation Current	X	
Impedance Voltage and Load Loss (Note 2)	X	
Temperature Rise		X
Dielectric Tests:		
Low Frequency, Partial discharge test (Note 3)	X	
Lightning Impulse (Note 4)		X
Ratio Influence Voltage (RIV)	X	
Insulation Power Factor	X	
Insulation Resistance	X	
Audible Sound Level (Note 5)		X
Short-Circuit Capability (Note 6)		X
Mechanical:		
Pressure	X	X
Leak	X	
Load Tap Changer (Note 7)	X	

D. Table Notes

1. Ratio test shall be performed on all tap positions of the load tap changer.

2. Short circuit impedance and reactance measurements shall be performed on the nominal tap position and on the extreme tap positions of the load tap changer.

3. Partial discharge measurement shall be performed during the induced voltage test to demonstrate that there is no damaging corona.

4. If the load tap changer is located at the center point of the secondary winding, the manufacturer shall ensure that the load tap changer will be subject to the full wave impulse voltage. The appropriate test procedure shall be submitted to the Engineer for approval. Impulse tests shall be performed with the LTC on nominal and extreme positions.

5. Sound level shall not exceed NEMA TRI, Table 1 when cooling fans are on and shall not exceed NEMA TRI, Table 1 during normal condition. The load tap changer shall be on the tap position on which the highest audible sound level is produces.

6. Short circuit test is required on one unit only.

7. Routine tests shall be performed on the load tap changer when completely assembled on the transformer. Routine test shall be performed in accordance with relevant standards.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Each outdoor type power transformer shall be installed on a concrete pad, and shall have oil containment berm, designed in accordance with manufacturer's instructions, and as indicated on the Contract Drawings. The design of the oil containment berm shall accommodate 110 percent of the volume of transformer oil that shall be provided by the manufacturer.

B. Transformer grounding shall conform to Contract Specifications Section 34 21 60, Grounding and Bonding for Traction Power Facilities.

C. Connect wiring to conform to Contract Specifications Section 34 21 50, Common Materials and Methods for Traction Power and Power Transformer.

3.02 EXAMINATION

A. Examine areas and conditions for compliance with requirements for the power transformers.

B. Examine roughing-in of conduits and grounding systems as indicated on the Contract Drawings.

C. Advise the District of any conditions that may hinder effective interface with the equipment.

3.03 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Insulation resistance test between windings, all windings to ground and core to ground using 2,500V DC megohmmeter.

2. Functional tests of protective devices.

3. Tap changer test with turn ratio test on all taps for proper tap setting.

4. Remove a sample of insulating liquid in accordance with ASTM D 923. Sample shall be tested for the following.

   a. Dielectric breakdown voltage: ASTM D877

   b. Acid neutralization number: ASTM D974

   c. Specific gravity: ASTM D1298

d. Interfacial tension: ASTM D 971.

e. Color: ASTM D 1500.

f. Visual Condition: ASTM D 1524.

g. Remove a sample of insulating liquid in accordance with ASTM D3612 and perform dissolved-gas analysis (DGA) in accordance with IEEE C57.104.

h. Verify operation of control cabinet space heaters.

B. Manufacturer's field services.

1. Factory-authorized service representative shall inspect field-assembled components and equipment installation, including connections and assist in field testing. Submit the report results in writing to the Engineer.

2. The manufacturer's representative shall provide technical direction and assistance in general assembly of the equipment, connections, and adjustments, and testing of the assembly and components contained therein.

3. The manufacturer's representative shall provide three copies of a written report on the installation and operational testing of the equipment in accordance with the manufacturer's written instructions. The manufacturer's representative shall list inspections and tests conducted and all results, including any problems found and how they were rectified. The manufacturer's representative shall certify equipment is ready for acceptance testing.

4. The manufacturer's representative shall be present to verify that the type of oil supplied, and the handling and filling procedures following installation at the substation sites, are in accordance with the manufacturer's recommendations.

3.04 CLEANING

A. On completion of installation, inspect the power transformers. Remove paint splatters and other spots. Vacuum dirt and debris. Compressed air shall not be used to assist in cleaning. Repair exposed surfaces to match original finish.

3.05 DEMONSTRATION AND TRAINING

A. A factory-authorized service representative shall demonstrate operation of equipment for the District's maintenance personnel to adjust, operate, and maintain power transformers, manual and automatic tap changers, surge arresters, current transformers, controls, protective devices, instrumentation, and accessories. Comply with the requirements of Contract Specifications Section 01 79 00, Demonstration and Training.

END OF SECTION 33 73 10

SECTION 33 83 01

RADIO NETWORK/TRUNKED RADIO SYSTEM

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Existing system description

B. Modification and additional requirements

C. System interface requirements

D. Radio systems location

E. Dispatcher console equipment

F. Installation, optimization, and field testing

G. Training and support

1.02 RELATED SECTIONS

A. Section 01 33 00, Submittal Procedures

B. Section 01 33 23, Shop Drawings, Product Data and Samples

C. Section 33 83 02, Radio Network/Monopole Antenna Tower

D. Section 33 83 03, Radio Network/Antenna System

E. Section 33 83 04, Radio Network/Distributed Fiber/Amplifier RF Radiating Cable System

F. Section 33 83 05, Radio Network/Regional High-Level Radio System

G. Section 33 83 06, Radio Network/Fiber Distributed Antenna Systems/Bi-Directional Radio Amplifier Systems

H. Section 33 83 07, Radio Network/Mutual Aid Radio System

1.03 MEASUREMENT AND PAYMENT

Separate measurement and payment will not be made for work required under this Section. All costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work of this Contract.

1.04 REFERENCES

A. Federal Communications Commission (FCC) Rules:

1. CFR Title 47 CFR, Telecommunications

B. MACOM Incorporated:

1. Document AE/LZT 123 4618/1, Site Grounding and Lightning Protection

C. National Public Safety Planning Administration Committee (NPSPAC) Region 6 (Northern California) planning regulations for 800 MHz Public Safety Agencies

D. Telecommunications Industry Association (TIA):

1. Technical Systems Bulletin, TSB 88-.1, .2, .3, .4, .5

E. US Department of Homeland Security (DHS):

1. Project 25 Compliance Assessment Program (P25 CAP)

2. Project 25 (P25 or APCO-25) – standard for digital radio communications

1.05 BART TRUNKED RADIO SYSTEM DESCRIPTION

A. The District owns and operates an 800 MHz radio network. Modifications to the radio network are anticipated over time due to upgrade and expansion of the BART system. It is planned to fully upgrade the BART radio to a P25 Phase 2 System by year 2025, through phased steps with full integration and operation between new and old systems. One element of the BART radio communications network is the trunked radio system, which facilitates communications above and below ground. The trunked radio system is used for voice communications between the Operations Control Center (OCC) and trains, BART police dispatch and police officers, coordination of maintenance workers, and administrative purposes. The system is used for both communications above and below ground. It is the primary real-time communication method for train control and for BART Staff throughout the District.

B. Radio base stations are located at the following sites:

1. BART base stations - 10 trunk channels

a. (e) Millbrae - EDACS

b. (e) Colma - EDACS

c. (e) Bernal Heights - EDACS

d. (e) Lake Merritt - EDACS

e. (e) El Cerrito Del Norte - EDACS

f. (e) Walnut Creek West - EDACS

g. (e) Willow Pass - EDACS

h. (e) Schaeffer Ranch - EDACS

i. (e) East Dublin - EDACS

j. (e) Bay Fair - EDACS

k. (e) Union City - EDACS

l. (e) Warm Springs - EDACS

2. BART High Sites - 2 single conventional channels

   a. Twin Peaks (SF)

   b. Vollmer Peak (Caldecott)

   c. Cummings Skyway (Crockett)

   d. Highland Peak (Dublin Grade)

3. Future sites or alternative coverage will be required for future extensions:

   a. SVBX San Jose Airport – Base Stations at Santa Clara and Alum Rock/ Berryessa

   b. Livermore

   c. Brentwood

The existing above ground Trunked Radio System is a 10 channel Enhanced Digital Access Communications System (EDACS™) simulcast system, as manufactured by MACOM/Ericsson/Harris Corp. It operates at 800 MHz, on National Public Safety Planning, Advisory Committee (NPSPAC) frequencies. New expansion and upgrade to a P25 Phase 2 System will use the same base channels for its trunked system, while expanding capacity to 18 operational voice channels with its time-slot architecture. Current BART simulcast channels are shown in Table 1.

Table 1: Current BART Simulcast Channels

EDACS BART Channel	BART MHz Tx	Trunked MHz Rx	12.5 kHz NPSPAC Channel
1	851.0375	806.0375	2
2	851.3125	806.3125	24
3	851.5625	806.5625	42
4	851.8875	806.8875	68
5	852.0375	807.0375	78
6	852.2375	807.2375	94
7	852.5625	807.5625	118
8	852.8125	807.8125	138
9	853.0375	808.0375	154
10	853.3625	808.3625	180

Additionally, there is a Harris Corp P25 Core and 6 channel Trunked Radio System for underground only use. Currently, this is only used for inter-agency interoperability, first responders and integration of new radio consoles above and beyond the capacity of the current EDACS System. The current BART simulcast “underground only” channels are shown in Table 2.

Table 2: Current BART Simulcast Underground Only Channels

P25 BART Channel	BART MHz Tx	Trunked MHz Rx	12.5 kHz NPSPAC Channel	Notes
1	851.6375	806.6375	48	In Underground Only
2	852.1625	807.1625	88	In Underground Only
3	852.3375	807.3375	102	In Underground Only
4	852.6500	807.6500	125	In Underground Only
5	853.6750	808.6750	205	In Underground Only
6	853.8625	808.8625	220	In Underground Only

Other conventional channels are also in-use. Current BART conventional BART High Sites and underground channels are shown in Table 3.

Table 3: Current BART Conventional High Site and Underground Channels

BART Conventional Channel ID	Used By	Duplex Systems Base Tx MHz	Base Rx MHz	CTCSS (Tx Only)	CAL Mut Aid Ch #	Notes
BART HL 2	BART PD	851.1000	806.1000	100.9		NPSPAC Ch. 4
CA HL FIRE 1	Mut Aid	853.9875	808.9875	156.7		In Underground Only
CA LL LAW 9	Mut Aid	851.2000	806.2000	156.7		In Underground Only
BART HL 1	BART	853.5375	808.5375	110.9		NPSPAC Ch. 194

C. The radio system is designed to provide clear, intelligible communication from portable radios with area coverage reliability of 95 percent or better. In some locations, radio signal penetration into wayside facilities is insufficient to provide this level of communication performance. The provision of Fiber Distributed Antenna Systems (Fiber DAS) or Bi-Directional Radio Amplifier (BDA) systems, with redundant delivery and adjacent UPS services within such facilities corrects for this condition.

D. In underground areas of the BART system, the trunked radio signals are propagated by a Commscope (formerly Andrews) Fiber DAS adjacent to each track on opposite tunnel sides. Independent base station radio feeds are used for each redundant Fiber DAS head-end node. These then send radio signals over fiber to redundant transmission nodes (Remote Units - RU) in each typically 2000 feet long RF segment; the RF segments use two Radiax (Coaxial Radiating Cable) cables for passive delivery, one for below ground radio transmission (downlink) and the other for reception (uplink). Each Fiber DAS node shall have its own 48 VDC UPS power capable of sustaining radio service greater than eight hours. Optical Fiber DAS with redundant delivery feeds from two ends of tunnel.

1.06 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Contract Specifications Section 01 33 23, Shop Drawings, Product Data and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit Shop Drawings including but not limited to the following:

1. Logical network diagrams.
2. Radio Frequency (RF) predictive coverage design maps.
3. Systems Block diagrams showing major gain or loss elements, all downlink single and combined and uplink power levels.
4. Network Management Systems (NMS) architecture.
5. Power Budget Diagrams.
6. Panel and cabinet layouts.
7. UPS protection systems.
8. Equipment interconnection diagrams.
9. Equipment and material lists.
10. Manufacturer’s descriptive and technical literature.
11. Equipment specification sheets and installation instructions.
12. If requested by the Engineer, a design review meeting shall be held in a District facility for the Contractor to present the required design submittal(s).
13. Design, validation, and test planning shall be submitted for equipment Factory Acceptance Testing (FAT), equipment installation, turn-on, configuration, testing and commissioning, failover, workmanship for RF transmission components and systems, RF systems sweep tests, RF PIM tests, optical Fiber DAS systems OTDR, RF signal strength coverage mapping, uplink power strength throughout coverage area, radio testing, voice quality, BER, DBER for all radio types, multiple unit testing, RF feed redundancy test, and diverse geographic testing.

C. Design validation, workmanship validation of components and systems, completion of test plans, coverage validation, core and application functionality, quality of radio service in all locations shall be completed before system is certified operational and commissioned.

PART 2 – PRODUCTS

2.01 DESIGN

A. General

1. The Trunked Radio System shall provide trunked radio coverage inside and around areas along the BART track alignment, at BART premises, offices, parking lots, above ground, below ground, inside tunnels, stations, subways, and trenches. At least 95 percent area coverage shall be provided inside the wayside facilities including that required for operational and mandated emergency services in passenger stations, parking garages, train control and communications room, traction power substations, maintenance yard and shops, revenue processing buildings, administration buildings, revenue vehicles, Park and Ride locations, and other BART facilities supporting train operations, maintenance, administration, engineering, and police activities. Above ground coverage shall extend 1.5 miles in both directions of the rail alignment at the prescribed performance levels. 95 percent coverage shall be considered for all individual work areas, rooms, structures and the whole RF coverage area.

2. The system reliability performance goals of the trunked system shall be with 95 percent coverage at 99 percent of the time. The system shall be balanced between talk out and talk in directions; mobile radios shall be set for 5-watt output and portables shall be set for 3-watt output. Coverage shall deliver performance deemed “loud and clear with occasional background noise”, and as defined in TIA Standard TSB 88-.1, .2, .3, .4, .5, Delivered Audio Quality (DAQ) shall be at 4.0 or above. The system reliability performance shall analyze the space inside of BART revenue vehicle (with closed doors) throughout the district trackway as a separately evaluated coverage area. Performance standards shall be based upon use of handheld portable radios and small antennas carried at the hip on the belt.

3. In underground trackway, stations, and facilities, a connection to the redundant units and UPS powered Commscope (formerly Andrews) Fiber DAS shall be deployed to extend the above ground trunked radio signals into the underground. The requirements for the distributed underground amplifier network are detailed in Contract Specifications Section 33 83 06, Radio/Bidirectional Radio Amplifier System and Section 33 83 04, Radio Network/Distributed Amplifier Radiating Cable System.

4. Trunked radio core and base station system equipment shall be designed to operate in an environmentally controlled facility, with continuous UPS power systems.

5. Trunked radio system equipment shall be housed in cabinets meeting current California Building Code Seismic Requirements, and cabinets shall be secured by current California Building Code seismic design stamped by a qualified California Licensed Engineer.

6. Trunked Radio System site equipment shall be powered by utility power with an automatic start generator-standby source, connected to the trunked system via an automatic transfer switch (ATS). Battery UPS shall be provided either as part of the generator, UPS, mains, ATS or within the equipment racks providing eight hours of back up, though trunked capacity can be temporarily downsized. The generator shall be sized to handle design operating loads for the radio equipment and supporting environmental equipment, with 30 percent spare capacity. The Trunked Radio System shall be provisioned for a minimum 2 days of absence of utility AC power without service interruption. UPS systems must be monitored and have alarms shown by the central Radio Management System.

7. Automatic Transfer Switches (ATS) for uninterrupted power supply to generator when utility power supply fails.

8. Antenna entrances to the trunked radio equipment facility shall be fully sealed and protected against lightning strikes.

9. Trunked radio coverage shall be made available above and below ground along the BART operating rail alignment and wayside facilities including the stations, their egress and emergency egress routes, yards and shops, Operations Control Center, maintenance facilities, police zone facilities, administrative offices, revenue processing facilities, and BART park and ride locations.

10. The system shall be designed and have assigned talk-groups for use by BART operations, maintenance, administration, engineering and police personnel.

11. The P25 system shall have Inter RF Subsystem Interface (ISSI) connections and specific talk-groups for inter-agency operations including fire, police, and other emergency agency personnel throughout the Bay Area along BART's right of way.

B. Modification and Additions

Modifications or additions to the system shall follow the design criteria:

1. Modifications, extensions, or upgrades to the Trunked Radio System design shall be fully compatible with and become an integral part of the existing radio network. The design approach shall show a complete installation process, maintaining an un-interrupted and fully functional radio operational system throughout the modification and addition duration.

2. The products shall utilize the Enhanced Digital Access Communication System (EDACS) format, as manufactured by MACOM, Inc. or future replacement technologies fully compliant with P25 systems.

3. Unless otherwise specified in the Contract, the Trunked Radio System shall be designed to operate as a GPS-coordinated simulcast system. It shall operate in the 800 Mhz radio band, and contain the 10 duplex 800 Mhz NPSPAC radio channels licensed by FCC and assigned to the District.

4. Trunked Radio System additions shall be next generation replacements or compatible with and provide, at a minimum, the same functions and operability as the existing trunked radio system. This shall include a remote network management capability, and interface to other BART and other agencies' radio systems. During upgrades to the existing BART EDACS system equipment, to establish compatibility to the new equipment, those upgrades shall become part of the Work, and during the Work the Trunked Radio System shall be fully operational and integrated between new and old elements.

5. An RF coverage assessment to evaluate the feasibility of the proposed extension to existing Trunked Radio System coverage shall be performed as part of the design planning exercise.

    a. Assessment shall consist of two parts:

        1) The first part is a computer-generated mapping showing predicted radio performance from each proposed radio site, as well as a composite model of all sites.

        2) The second part is a drive test to verify real world performance of the computer modeling predictions. Signal strength, urban clutter, and simulcast time domain interference over the BART right of way are minimally required in the computer prediction.

        3) An assessment of RF redundant coverage shall be modelled and plotted in mapping software.

6. Existing system coverage modifications, if required, shall be developed and shown in the predictive mapping of extension sites.

7. A performance guarantee from the manufacturer/designer shall accompany the RF coverage assessment, and if coverage performance is not met, then the designer/manufacturer will be responsible for achieving the required coverage area and performance as a part of current contracts.

8. Though primarily an above ground system, the Designer shall include the equipment and designs necessary to furnish the trunked radio signals into the existing BART underground and trenches by interface to the Fiber DAS or BDA systems and specified buildings by either adequate trunked RF signals, by enhancement by DAS equipment, or by addition of Bi-Directional Amplifier (BDA) equipment to meet specified performance levels.

2.02 SYSTEM INTERFACE REQUIREMENTS

A. Audio, data, and control signals to and from each newly proposed shall interface with the existing EDACS control point radio equipment at Lake Merritt and future redundant P25 Radio Core(s) locations, which shall also be configured to be compatible with the requirements of the BARTnet, UON, IP and MPL Networks.

B. Below ground redundant radio coverage shall be provided to subway stations, trenches and tunnel areas, and shall be designed to interface with the radio network equipment in a manner similar to that of the existing below ground radio communication equipment throughout the District. Typically, fiber optic cables are

used to transfer the RF signal between tunnel section equipment and specific above ground radio site equipment. An interface to the underground equipment at the trunk radio site shall be provided in system design. The District uses a Commscope (formerly Andrews) Fiber DAS and Andrew Integrated Management Operation System (AIMOS), Network Management System, and new installations shall be fully compatible with these existing systems, integrating to Commscope (formerly Andrews) monitoring system.

2.03 RADIO SYSTEMS LOCATION

A. Newly proposed transmit sites shall be located to obtain the specified system radio coverage and reliability percentages required. New transmit site facilities shall be protected from existing sources of signal interference to prevent degradation to the Trunked Radio System.

B. New trunked radio site locations shall be placed upon District-owned property or projected-District-owned property along the right-of-way if possible. If the location of District property is not suitable for establishing radio coverage performance, then the Designer shall attempt to find space in an existing and developed radio facility. Failing that, other off-site property locations may be evaluated.

C. Radio Shelter: The Trunked Radio equipment radio system shall be installed in an environmentally controlled communication shelter.

1. The shelter shall be provided with a concrete exterior; AC and UPS power distribution; generator; smoke, heat and power fail detection; interior lighting; a halo ground system; and a bullet-proof door.

2. The shelter shall be as specified herein and in the Contract.

2.04 DISPATCHER CONSOLE EQUIPMENT AND CONTROL POINT RADIOS

Personal computer (PC) based trunk radio dispatch console system and control point radios shall be provided in Operations Control Center, police dispatch centers, and in yard control towers. The system shall be a Designated Matching Product to the radio system, C3 Maestro console system or later compatible evolutions, as manufactured by MACOM Inc./Harris Corp, or units with Console Subsystem Interface (CSSI) integration capabilities for current radio systems. The system shall interface and integrate to the existing EDACS control point and P25 VIDA Core control point or future installed radio equipment at Lake Merritt. Control point radios shall be connected to proper antenna arrays and designed to receive strong over the air radio systems signals and perform to DAQ 5.0 levels.

PART 3 – EXECUTION

3.01 INSTALLATION

A. The radio system elements and backup electric power housing shall be located adjacently. The shelter or equipment room where the radio equipment is mounted shall have access to the building halo or electrical ground system and shall have an efficient HVAC system, generator, and battery UPS system.

B. Installation work shall be completed to the site-specific drawings, weather-proofing and grounding details, and Contract Documents.

3.02 SYSTEM OPTIMIZATION

A. Each base station shall be optimized for coverage and performance. It shall then be integrated into the full BART Radio Network System, without any deterioration of service throughout any part of the BART Radio Network System.

3.03 FIELD TESTING

A. Work shall be performed to complete the testing set out in the test planning Submittals, Contract Drawings, and Contract Specifications.

B. Field testing shall verify that the radio systems equipment has been installed in accordance with the Contract and the system performance criteria. Include inspection, test and measurements of the DC power, turn on and burn in, ground tests, RF components and RF passive system sweep tests, drive test results, the GSI coverage maps for Received Signal Strength Indication (RSSI), uplink power levels, radio voice quality, and BER DBER testing. Test measurements shall be structured and provide a grid and tile granularity for the recorded data.

C. As-built diagrams showing equipment placement and routing for antennas, coaxial cables, AC power, system and network design drawings shall be provided to the District prior to acceptance testing. An RF compliance certificate shall be submitted for each radio system and the systems as a whole at the conclusion of the acceptance testing.

3.04 TRAINING, MANUALS, SPARES, AND SUPPORT

A. Operating manuals, electronic documents including native file formats, and system(s) configurations and back-ups shall be provided, at each equipment location. Copies shall be provided to BART Engineering and Maintenance.

B. Training shall be conducted by the Original Equipment Manufacturer (OEM) or OEM partner engineering staff at District premises for District staff. Sufficient quantity shall be provided to allow staff from all shifts to complete training, in small class sizes.

C. Spares shall be available for the systems for at least 15 years from purchase, and if any components become unavailable, then OEM or OEM partners shall redesign replacements at no cost to the District, to keep equipment fully functional for its life-span.

D. OEM or OEM partners shall provide 24 hours a day, 365 day support with knowledgeable Tier 1 through 4 support staff available to support the systems for 15 years after Acceptance.

E. OEM or OEM partner shall provide recommended preventative maintenance schedules and spares for all equipment.

END OF SECTION 33 83 01

SECTION 33 83 02

RADIO NETWORK/MONOPOLE ANTENNA TOWER

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Design of monopole and foundation site grounding and lightning protection.

B. Fabrication of structural steel.

C. Construction of foundation.

D. Erection of the monopole.

E. Welding of the monopole.

F. Installation of site grounding and lightning protection and all tower appurtenances.

G. Safety Systems.

1.02 RELATED SECTIONS

A. Section 33 83 03, Radio Network/Antenna System

1.03 MEASUREMENT AND PAYMENT

All work required under this Section will be measured separately for payment as part of the Contract lump-sum price, as part of the related item of work, as indicated on the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM A36/A36M Specification for Carbon Structural Steel
2. ASTM A53/A53M Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
3. ASTM A123/A123M Standard Specification for Zinc (Hot-Dipped Galvanized) Coatings on Iron and Steel Products
4. ASTM A394 Standard Specification for Steel Transmission Tower Bolts, Zinc-Coated and Bare
5. ASTM A563 Standard Specification for Carbon and Alloy Steel Nuts
6. ASTM A572/A572M Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Steel

7.	ASTM B695	Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel
8.	ASTM C33/C33M	Standard Specification for Concrete Aggregates
9.	ASTM C94/C94M	Standard Specification for Ready-Mix Concrete
10.	ASTM C150/C150M	Standard Specification for Portland Cement
11.	ASTM F3125/ F125M	Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi (830 MPa) and 150 ksi (1040 MPa) Minimum Tensile Strength, Inch and Metric Dimensions
12.	ASTM A615/ A615M	Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement

B. American Concrete Institute (ACI):

1.	ACI 318	Building Code Requirements for Structural Concrete and Commentary

C. American Institute of Steel Construction (AISC):

1.	AISC 360	Specification for Structural Steel Buildings

D. American National Standards Institute (ANSI):

1.	ANSI/ASSE Z359	Fall Protection Code
2.	ANSI/TIA 222	Structural Standard for Antenna Supporting Structures and Antennas and Small Wind Turbine Support Structures

E. American Welding Society (AWS):

1.	AWS D1.1/D1.1M	Structural Welding Code, Steel

F. California Building Code (CBC)

G. MACOM Incorporated:

1. Document AE/LZT 123 4618/1, Site Grounding and Lightning Protection

H. National Fire Protection Association (NFPA), National Electric Code (NEC):

1.	NFPA 70NEC Article 392	Cable Trays

I. National Electrical Manufacturers Association (NEMA):

1. NEMA VE 1 Metallic Cable Tray Systems

J. Occupational Safety and Health Administration (OSHA):

1. OSHA Worker Fall Protection Codes

1.05 SUBMITTALS

A. General: Refer to Contract Specifications Section 01 33 00, Submittal Procedures, and Contract Specifications Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Product Data: Submit manufacturer's specifications for materials.

C. Shop Drawings and calculations shall be submitted within 20 Days of the effective date of the Notice to Proceed. Shop Drawings and calculations submitted that come under the jurisdiction of the California Professional Engineers Act shall conform to the Act and bear the seal and signature of a California Civil or Structural Engineer. The following items shall be submitted for approval:

1. Monopole summary loading conditions, elevations of tower, and the maximum number and types of components, with heights, that will be attached to the tower and platforms.

2. Monopole structural detail drawings showing plate sizes, required welds and detail of splices.

3. Foundation design drawings showing details of anchor bolts, reinforcing bars and other embedded items.

4. Plot plan showing monopole foundation location.

5. Erection plan.

6. Calculations for monopole and its foundation.

7. Site geotechnical report.

8. Site grounding and lightning protection design and details.

1.06 WARRANTY

A. Tower structures shall have a warranty of 5 years after the date of Acceptance.

PART 2 – PRODUCTS

2.01 DESIGN

A. Monopole:

1. The design of the pole, platform, and antenna support shall meet ANSI/TIA 222 and the California Building Code. Steel members, lightning rod, platform, and climbing facilities shall be galvanized.

2. Monopole shall be galvanized structural steel 150-foot or as otherwise specified in design documents, high self-supporting pole with multiple sided cross section in plan.

3. A manufactured triangular platform shall be provided at the top of the monopole. Height shall be manufacturer standard. Platform shall be equipped with structural members to support and mount the equipment shown in Table 1 or equipment required by the Radio Frequency (RF) coverage design.

Table 1: Equipment to be Supported by the Platform

Qty	Item	Purpose	Azimuth	Ht (ft)/wt (lb)
1	Antenna	Receive	Omni	16/66
1	Amplifier	Tower Top	---	3/25
1	Antenna	Test	Omni	15.3/66
2	Antenna	Transmit	Directional	13.4/50 each

4. Monopole shall be equipped with manufacturer standard lightning rod at the top and shall be attached so as to extend a minimum of 18 inches above the highest point of the monopole including all attachments.

5. Monopole shall be equipped with protective grounding and climbing facilities that conform to ANSI/TIA 222.

6. Monopole shall be equipped with support for cable ladder tray.

7. Cable ladder tray shall be provided between monopole and existing station building.

8. Wind loading shall be designed in accordance with the provisions of CBC, design based on Risk Category IV and Exposure C.

9. For seismic loading, use Importance Factor of 1.5.

10. Radial ice shall be 0 inches.

11. Maximum monopole twist and sway due to design wind loading shall be less than two (2) degrees.

12. The tower and foundation shall be installed with site grounding and lightning protection that conforms to Industry Standard “Site Grounding and Lightning Protection” from MACOM, Document AE/LZT 123 4618/1.

B. Foundation Requirements:

1. Contractor shall design tower with safety features, such as climbing pegs, ladders, safe to climb devices, platforms, and crow’s nest as appropriate.

2. Contractor shall obtain a geotechnical report on the site. A copy of the report shall be provided to the District. There is no guarantee expressed or implied that the conditions indicated in the report are representative of those existing throughout the job site or that unforeseen developments may not occur. If at the time of excavation, the Contractor finds soil conditions that are significantly different than stated in the report, notify the Engineer immediately.

2.02 MATERIALS

A. Steel:

1. Structural steel shall conform to ASTM A36/A36M for medium steel and ASTM A572/A572M, Grade 65 for high-strength steel.

2. Structural steel pipes and antenna mounts shall conform to ASTM A53/A53M, Grade B.

3. Assembly bolts shall conform to ASTM F3125/3125M or ASTM A394 (Type 1 or 2). Nuts shall conform to ASTM A563 and be of grade and style suitable for use with bolts supplied. Nuts for F3125/3125M bolts shall be heavy hex nuts.

4. Monopole and supports shall be hot-dipped galvanized per ASTM A123/A123M. Monopole and other tubular members shall be galvanized both inside and outside. Fasteners shall be mechanically galvanized per ASTM B695.

5. Welding rods shall conform to AWS D1.1/D1.1M.

B. Reinforced Concrete:

1. Concrete shall be Class 3000 with maximum aggregate size of 1 1/2 inches per Contract Specifications Section 03 05 15, Portland Cement Concrete. Slump shall be as low as practicable to produce a dense, well-consolidated concrete, and not exceed 4 inches unless otherwise authorized by the Engineer.

2. Reinforcing bars shall be deformed billet steel, Grade 60, conforming to ASTM A615/A615M, except that the maximum yield strength shall be 78,000 psi, and the tensile strength shall not be less than 1.25 times the actual yield strength.

C. Site Grounding and Lightning Protection:

1. As required by MACOM Document AE/LZT 123 4618/1 R3A.

PART 3 – EXECUTION

3.01 INSTALLATION

A. The Contractor shall notify the Engineer at least one week before the start of field work. Locations of underground utilities are shown on the Contract Drawings. Contractor must receive approval from the Engineer prior to excavation of foundation.

B. Forms shall be constructed true to the lines and dimensions shown on the Contract Drawings.

C. Reinforcing bars and tower anchor bolts shall be accurately placed and securely held in place during placing of concrete. Ties shall be drawn up tight.

D. Top of footing shall be given a steel trowel finish.

E. Monopole shall not be erected on concrete that has been in place less than 28 calendar days. Erection may proceed only when the concrete has acquired enough strength to support the steel and has been authorized by the Engineer.

F. Installation of portions of monopole shall be accurately plumbed, aligned, leveled and shall be braced as required for safety, for accuracy of placement and carry loads to which they may be subjected. Maximum deviation from a straight line between any two points shall not exceed 1 part in 1000.

3.02 PERIODIC INSPECTIONS AND TOWER MAINTENANCE DURING WARRANTY PERIOD

A. Tower structures in the California Bay Area are subject to harsh conditions, of sea air, mists, winds, and sun. Tower structures shall be inspected by qualified engineers every 3 years, with a maximum interval of 5 years during the warranty period.

B. Logs of tower maintenance required from these inspections shall be kept, with severity and the inspecting engineer shall recommend a timeline that these identified repairs shall be completed by. Tower maintenance identified repairs shall be completed before the end of warranty period.

END OF SECTION 33 83 02

SECTION 33 83 03

RADIO NETWORK/ANTENNA SYSTEM

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Antennas.

B. Tower top amplifiers.

C. Radio frequency (RF) cables and connectors.

D. Materials and Equipment.

E. Equipment Grounding.

F. Installation, optimization, and field testing.

G. Training and support.

1.02 RELATED SECTIONS

A. Section, 33 83 02, Radio Network / Monopole Antenna Tower

B. Section 01 33 00, Submittal Procedures

C. Section 01 33 23, Shop Drawings, Product Data, and Samples

D. Section 01 43 00, Quality Assurance

E. Section 01 45 00, Quality Control

1.03 MEASUREMENT AND PAYMENT

All work required under this Section will be measured separately and will be paid for as part of the Contract lump-sum price, as part of the related item of work, as indicated on the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM A123/A123M	Standard Specification for Zinc (Hot-Dipped Galvanized) Coatings on Iron and Steel Products
2. ASTM A563	Standard Specification for Carbon and Alloy Steel Nuts
3. ASTM B695	Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel

B. Federal Communications Commission (FCC):

1. FCC Rules and Regulations Title 47 CFR

C. Institute of Electrical and Electronic Engineers (IEEE):

1. IEEE Standard 81 Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System

D. National Fire Protections Association (NFPA):

1. NFPA 70 National Electric Code (NEC):

a. NEC Article 392 Cable Tray

b. NEC Article 376 and 378 Metal Wireways and Nonmetallic Wireways

E. National Electrical Manufacturers Association (NEMA):

1. NEMA VE 1 Metal Cable Tray Systems

2. NEMA WD 1 General Color Requirements for Wiring Devices

F. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE C2 National Electrical Safety Code (NESC)

G. MACOM Incorporated:

1. Document AE/LZT 123 4618/1, Site Grounding and Lightning Protection

1.05 SUBMITTALS

A. Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. The Contractor shall submit the following:

1. Shop Drawings showing the layout of the system identifying the location of equipment and accessories.

2. Testing plan for products used for the radio network antenna systems and the full systems from the radios to the antenna, ensuring the designed Radio Frequency (RF) Effective Isotropic Radiated Power (EIRP) is met.

3. Manufacturer’s product data for manufactured items of materials, equipment, and accessories shown on the Shop Drawings.

4. Test reports of tests conducted by the Contractor.

5. Certificates certifying that the equipment tested is ready for use.

1.06 QUALITY ASSURANCE

A. Quality Assurance and Quality Control (QA QC) Sections 01 43 00 and 01 45 00 shall be used for QA QC work, testing, and validation.

B. The system shall be designed and installed by an experienced and qualified individual of firm regularly engaged in the design and installation of such systems.

C. Materials shall be clearly marked with the manufacturer's name, nameplate data or stamp, rating, and conformance with standards, with corresponding standard number clearly marked, as applicable.

D. Material and equipment shall be tested and shall be listed by a nationally recognized testing laboratory.

E. Installed equipment shall be for service in a land mobile radio environment. They shall be of latest types or models, consistent with the present state of the art; and be constructed for service life time of not less than 15 years. The equipment shall employ technologically advanced design techniques to provide an operating system that will perform as specified herein in these specifications.

F. Fully trained, knowledgeable, and qualified technicians and engineers shall be used for the testing to current industry best practices.

1.07 SITE CONDITIONS

A. Verify existing conditions prior to the start of any work. Notify the Engineer to gain entrance to the train control room to inspect the radio equipment including the radio cabinets.

B. Coordinate the installation of the system with other building systems and components to avoid conflicts.

C. Contract Drawings for the radio system are diagrammatic and not necessarily to scale.

PART 2 – PRODUCTS

2.01 ANTENNAS

A. Radio Antenna System shall be as specified in the Contract, and shall be a Designated Matching Product (DMP) with quantities as shown in the Shop Drawings:

1. Transit Antenna

2. Receive Antenna

3. Test Antenna

4. GPS Antenna

2.02 TOWER TOP AMPLIFIER

The tower top amplifier shall be a Designated Matching Product with test port and bandwidth filtering, or an approved equal that meets the radio system's OEM specifications.

2.03 RADIO FREQUENCY CABLE AND CONNECTORS

A. 7/8-inch Diameter RF Coaxial Cable:

1. 7/8-inch diameter size or larger.

2. Low-density foam, dielectric insulation.

3. Corrugated copper outer conductor material.

4. Copper-clad aluminum wire inner conductor material.

5. Special jackets with "plenum" rating.

6. Heliax LDF 7-50 coaxial cable or equal.

B. 1/2-inch Diameter RF Coaxial Cable:

1. 1/2-inch diameter size.

2. Low-density foam, dielectric insulation.

3. Corrugated copper outer conductor material.

4. Copper-clad aluminum wire inner conductor material.

5. Special jackets with "plenum" rating.

6. Heliax LDF 4-50 coaxial cable or equal.

C. RF Coaxial Connector Type:

1. As specified in the RF Coverage Design.

2.04 CABLE TRAY

A. Ladder type cable trays shall be provided, and they shall be grounded across joints.

2.05 ACCESSORIES

A. Accessories required for a complete antenna system shall be provided.

2.06 EQUIPMENT GROUNDING

A. The cabinet shall be grounded to the Train Control Room equipment ground bus.

B. The grounding conductor shall be installed in a separate conduit to the train control room ground bus.

C. Ground connections shall be tight, free of paint, and suitably protected from physical damage and corrosion.

D. Ground leads shall be short, direct, and shall have number 6 AWG minimum size.

E. The ground resistance between each bus and prime communications grounding shall be less than 0.5 ohm.

F. The contractor shall record the resistance from each ground connection to the ground bus.

G. Only one path shall exist between the train control room prime ground bus bar and ground. Disconnecting the leads from the bar to ground shall show a dc resistance from the bar to ground of over 100K ohm.

H. Cabinets shall be isolated from other pieces of equipment. 1M ohm shall be the minimum resistance between them.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Contractor shall provide and install all brackets, antennas, tower top amplifier, radio frequency cable, connectors, conduit, cable trays, and other accessories as required and per Contract Drawings.

B. The new monopole shall be installed with antennas and amplifier aligned, cables routed, connectorized, and tested.

C. Overall system shall be placed into service before the existing monopole and equipment mounted to it may be removed.

D. Unless otherwise specified, no old equipment shall be reused in the new installation.

E. RF cable connecting to the new monopole-mounted antennas and amplifier, and GPS antennas, shall be routed to and connected to a new site.

F. Grounding and lightning protection shall be installed at the point of cable entrance into the existing train control room.

G. RF cable shall be installed in conduit or ladder tray, as depicted in the design drawings.

H. Vertical cable support on the tower shall be as recommended by the tower manufacturer.

I. New conduit and ladder trays shall be grounded per lightning protection and NEC requirements.

J. RF cable shall be routed as depicted in the plans from the new lightning protection to the radio transmitter cabinet number 5 inside the train control room by way of the overhead cable ladder.

K. Cable connectors shall be placed on the end of the cables, but not terminated into the cabinet.

L. Lightning protection installation shall be in accordance with Harris Incorporated Document AE/LZT 123 4618/1, Site Grounding and Lightning Protection.

M. The radio antenna system shall be fully tested, and RF components and systems be fully sweep or PIM tested by the Contractor at the transmitter equipment cabinet connection point through to antennas or radiating equipment in the presence of BART personnel and be certified ready for use.

N. Contractor shall accommodate the Engineer to make the final termination of the new work to the existing radio equipment cabinets for the final performance test.

O. Test data, performance data, and plots shall be submitted to BART as part of the Record Documents.

P. Equipment and systems testing procedures used shall be in accordance with the current RF component and systems best practices used in the LMR and Cellular Communications Industries.

Q. If later additions or changes are made to the antenna systems, then added equipment shall be fully tested in the presence of the Engineer, and systems re-swept and re-certified from the point of transmission to radiating antennas.

3.02 FIELD QUALITY CONTROL

A. Contractor shall test the antenna system prior to final connection to radio equipment cabinets and certify that they are ready for use.

B. Contractor shall perform all tests in the presence of the Engineer and BART personnel.

C. Contractor shall furnish all items used in testing.

D. The Contractor shall give notice 48 hours prior to test.

E. The contractor shall provide the test reports and certificates for the Engineer to review.

F. Final connection to the existing radio equipment cabinets will be performed by designated District representatives.

G. Equipment, lines, and weatherproofing shall be visually inspected in the presence of the BART Radio Engineers representative.

H. The effective performance of the System shall be reviewed annually for the duration of the Contract and warranty.

3.03 FIELD TESTING

A. Work shall be performed to complete the testing set out in the test planning submittals, Contract Drawings, and Specifications.

B. Verify that the radio systems equipment has been installed in accordance with the Contract Specifications, Contract Drawings, and the system performance criteria. This shall include inspection, test and measurements of the DC power, ground tests, RF components sweep tests, the coverage maps, system configuration and attenuation settings on updated power block diagram, Radio Voice Quality DAQ, and BER testing. Record all test measurements. Provide diagrams showing equipment placement and routing for antennas, coaxial cables, and AC power to the District's Representative prior to acceptance testing. Power and network configuration settings shall be supplied with each test report. Submit an RF compliance certificate for each radio system at the conclusion of the acceptance testing.

3.04 TRAINING, MANUALS, SPARES, AND SUPPORT

A. Full operating manuals and electronic documents shall be provided at each equipment location. Copies shall be provided to BART Engineering and Maintenance Departments.

B. Training shall be conducted by the Original Equipment Manufacturer (OEM) or OEM partner engineering staff at BART premises for both engineering and maintenance engineers and technicians. Sufficient quantity shall be set up to allow staff from all shifts to complete training in small class sizes.

C. Spares shall be available for the Systems for 15 years from purchase, and if any components become unavailable, then OEM or OEM partners shall redesign replacements at their own cost, to keep equipment fully functional for this life-span.

D. OEM and OEM partners shall provide 24-hour support and support centers with knowledgeable tier 1 through 4 support staff available to support the systems for life of the product.

3.05 PREVENTATIVE MAINTENANCE SCHEDULES

A. OEM or OEM partner shall provide full preventative maintenance procedures and schedules for equipment and systems.

END OF SECTION 33 83 03

SECTION 33 83 04

RADIO NETWORK/DISTRIBUTED AMPLIFIER RADIATING CABLE SYSTEM

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Existing system description.

B. Radiating coaxial cable.

C. System requirements.

D. Installation, optimization, and field testing.

E. Maintenance, manuals, training, and support.

1.02 RELATED SECTIONS:

A. 01 33 00, Submittal Procedures

B. 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures

C. 33 83 01, Radio Network/Trunked Radio System

D. 33 83 05, Radio Network/Regional High-Level Radio System

E. 33 83 06, Radio Network/Bi-Directional Radio Amplifier System

F. 33 83 07, Radio Network/Mutual Aid Radio System

1.03 MEASUREMENT AND PAYMENT

All work required under this Section will be measured separately and will be paid for as part of the Contract lump-sum price, as part of the related item of work, as indicated on the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. Association of Public Safety Communications Officials International (APCO):

1. APCO Project 25 Standards for Digital Trunk Radio Communications

B. Federal Communications Commission (FCC):

1. FCC Rules and Regulations Title 47 CFR, Telecommunications

C. National Electrical Manufacturers Association (NEMA)

D. National Public Safety Planning Administration Committee (NPSPAC):

1. NPSPAC Northern California Region 6 Plan

E. United States Department of Homeland Security (DHS):

1. DHS Project 25 Compliance Assessment Program (P25 CAP)

1.05 SUBMITTALS

A. Refer to Contract Specifications Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. The Contractor shall submit the design, validation, and test planning report for the following:

1. System Design
2. Downlink and uplink power block design drawings
3. Test planning submittals
4. Factory Acceptance Testing (FAT)
5. Equipment installation
6. Turn-on
7. Configuration
8. Testing and commissioning
9. Workmanship for RF transmission components and systems
10. RF systems sweep tests
11. RF PIM tests
12. Optical Fiber DAS systems, OTDR test in both directions
13. RF signal strength coverage mapping
14. Detailed system configuration and tuning of downlink and uplink
15. Radio testing, voice quality
16. Bit Error Rate (BER) testing for all radio types (digital/analogue)
17. Multiple unit testing, including diverse geographic locations

C. Design validation, workmanship validation of components and systems, completion of test plans, coverage validation, core and application functionality, and quality of radio service in all locations shall be completed before system is certified operational and turned-on.

D. Shop Drawings showing the layout of the system identifying the location of equipment and accessories.

E. Manufacturers' product data for all manufactured items of materials, equipment, and accessories shown on the Shop Drawings.

F. Submit calibration certificates with greater than three months prior to expiration date, for test measurement equipment used by Contractor.

G. Test reports of tests conducted by the Contractor.

H. Certificates certifying that the equipment tested is ready for use.

1.06 DESCRIPTION

The District owns and operates an 800 MHz radio network. Modifications, coverage expansion, and upgrades or replacement to new radio products or technologies of the radio network are anticipated over time due to expansion and higher utilization of the BART system. The Fiber Distributed Antenna Systems (Fiber DAS) are one element of the BART radio network. Radio signals generated by other elements of the BART Radio Network are connected to and then distributed by the Fiber DAS into the underground trackway, trenches, stations, and facilities. BART currently uses the Harris EDACS and P25 Radio Systems and all the channels broadcast from these are repeated underground.

The existing BART Operational above ground trunked radio system is a 10 channel Enhanced Digital Access Communications System (EDACS™) simulcast system, as manufactured by MACOM/Ericsson/Harris. Later this will be refreshed to current Radio Systems product offering, likely P25 phase 2 when NPSPAC 6.25 KHz channels will be used.

BART has only deployed Andrews Fiber DAS and BDA fully redundant system throughout its tunnels, which are approximately 30 percent of its rail network. Each cell segment of underground coverage is approximately 2000 feet long, and has redundant radio feeds, UPS, and BDA at either ends. The Andrews Integrated Management Operating System (AIMOS) has its own full coverage Network Management System (NMS) reporting all functionality and graded alarms. This system has its own eight-hour minimum 48 VDC UPS System at each nodes. BART's Operational EDACS channels are shown in Table 1.

Table 1: BART's Operational EDACS Channels

EDACS	BART	Trunked	12.5 kHz
BART	MHz	MHz	NPSPAC
Channel	Tx	Rx	Channel
1	851.0375	806.0375	2
2	851.3125	806.3125	24
3	851.5625	806.5625	42
4	851.8875	806.8875	68
5	852.0375	807.0375	78
6	852.2375	807.2375	94
7	852.5625	807.5625	118
8	852.8125	807.8125	138
9	853.0375	808.0375	154
10	853.3625	808.3625	180

Additionally, there is a Harris Corp P25 Core and 6 channel Trunked Radio System for underground only use. Currently this is only used for inter-agency support, and integration of consoles above the capacity of the EDACS system. BART's current simulcast underground only channels are shown in Table 2.

Table 2: BART's Current Simulcast P25 Underground only Channels

Current BART Simulcast U/G P25 Only Channels

P25	BART	Trunked	12.5kHz	
BART	MHz	MHz	NPSPAC	
Channel	Tx	Rx	Channel	Notes
1	851.6375	806.6375	48	In Underground Only
2	852.1625	807.1625	88	In Underground Only
3	852.3375	807.3375	102	In Underground Only
4	852.6500	807.6500	125	In Underground Only
5	853.6750	808.6750	205	In Underground Only
6	853.8625	808.8625	220	In Underground Only

Other conventional channels that are in-use is shown in Table 3.

Table 3: Current BART Conventional High Site and Underground Channels

BART Conventional		Duplex Systems		12.5 kHz		
Channel	Used	Base Tx	Base Rx	CTCSS	CAL Mut	
ID	By	MHz	MHz	(Tx Only)	Aid Ch #	Notes
BART HL 2	BART PD	851.1000	806.1000	110.9		NPSPAC Ch. 4
CA HL FIRE 1	Mut Aid	853.9875	808.9875	156.7		In Underground Only
CA LL LAW 9	Mut Aid	851.2000	806.2000	156.7		In Underground Only
BART HL 1	BART	853.5375	808.5375	110.9		NPSPAC Ch. 194

The existing BART U/G segments and head-end radios locations are:

- Underground (U/G) Fiber DAS (Bi Directional Amplifiers) – ALL ANDREWs
- Channels – 10 Trunk EDACS, 6 Trunk P25, 2 High, 2 St Fire
    - Millbrae /Colma Tunnel | HE1 W40 Millbrae | HE2 W10 Colma(1)
    - Balboa /SF to Civic Tunnel | HE1 W10 Colma(2) | HE2 LMA(1)
    - Civic to TTB Tunnel | HE1 W10 Colma(3) | HE2 LMA(2)
    - WYE Tunnel | HE1 LMA(3) | HE2 R50 EL C Del N(1)
    - Berkeley Tunnel | HE1 LMA(4) | HE2 R50 EL C Del N(2)
    - Chabot /Berkeley Hills Tunnel | HE1 LMA(5) | HE2 C30 WC West(1)
    - MacArthur Tunnel | HE1 LMA(6)
    - Hwy 238/580 Tunnel |HE1 LMA(7)
    - Walnut Creek Tunnel | HE1 WC West(2)

BART has deployed District Designated Product, Fiber DAS manufactured by Commscope (formerly Andrews) with fully redundant head-end and Commscope fully redundant remote end fiber optical based DAS systems, providing RF signal to each different end of Passive RF Leaky Coax (Radiax) System Segments (generally 2000 feet in length). All BART Commscope Systems have a Commscope, Andrew Integrated Management Operation System (AIMOS) Control and Monitoring System, using fixed software release level. All new units shall be fully compatible with BART's existing Commscope System and Commscope AIMOS Control /Monitoring System.

BART has only deployed District Designated Product Commscope in-Building BDA Systems. Prior models are Andrews (acquired by Commscope) Node A 4, with LMR module AF 8037.

The radio system is designed to provide clear, intelligible communication from portable radios within the tunnel and building area coverage reliability of 95 percent or better. In some locations, radio signal penetration into tunnel and wayside facilities are insufficient to provide this level of communication performance. The provision of a Fiber DAS system or Bi-directional Radio Amplifier (BDA) system, supported with a local 48 VDC UPS power and battery system, providing eight hours of use on mains power failure, within such a facility corrects for this condition.

PART 2 – PRODUCTS

2.01 DESIGN

A. The Fiber DAS system is a District Designated Matching Product (DMP) and shall be composed of electronic equipment that accepts, combines, splits, processes, and amplifies radio signals, and a passive RF cabling system for distribution of those signals into the BART underground.

1. Below ground radio coverage shall be provided in all subway stations and tunnel areas. Radio coverage shall be made available along the BART operating alignment and wayside facilities. This includes the trackway, both public and secured areas of passenger station concourses and platforms. Highly sensitive sites such as fire command posts; and areas near electrical alarm panels. BART facilities shall be provided with coverage as indicated.

2. The DAS system shall be designed to interface with other elements of the BART radio network in a manner similar to that used by the existing in-service equipment. This generally consists of a transmit and a receive RF signal interface from the trunked radio system, the mutual aid system, and the regional high level system. Each RF input is separately derived and applied to the DAS system.

3. The Fiber DAS system shall consist of necessary equipment for processing, amplification, channelizing, and distribution of selected radio channels. It shall have capacity for operating with BART-use radio channels. It shall also have four channels for future inter-agency operations including fire, police, and other emergency agency personnel. Other channels shall be rejected.

4. The Fiber DAS system shall be constructed in a redundant manner. Radio feeds into the tunnel sections shall be fed from a “north” radio site, and from a “south” radio site. At each bidirectional amplifier node, two separate bidirectional amplifiers shall be provided: one connected to the north feed source, one from the south feed source. The two amplifiers shall be coordinated so that only one is in service at a time but will automatically connect to the other in case of an amplifier failure, feed source failure, or when manually commanded by the AIMOS.

5. Interconnection between the DAS tunnel portal radio feeds and the DAS radio network signal interface, co-located with specific trunked radio sites, shall be by single mode fiber optic cable .

6. DAS Radio System design and equipment shall adhere to applicable codes and regulations, including Federal Communications Commission (FCC) rules, and National Public Safety Planning Administration Committee (NPSPAC) Region 6 (Northern California) planning regulations for 800 MHz public safety agencies. Transmitting equipment shall be FCC type certified.

7. Equipment deployed outside of an environmentally controlled facility shall be housed in a NEMA 4 box, and suitable for operation at temperatures of 40 degrees Celsius.

8. Equipment installed in an environmentally controlled facility shall be mounted in a cabinet in compliance to California Building code.

9. The Fiber DAS shall provide radio coverage with radio signal strength between -90 dBm and -65 dBm, for over 95 percent of the coverage area of BART trackway, public areas of BART Passenger facilities, and other maintenance or operational facilities. Coverage area shall include the inside of BART revenue vehicles, while moving at speeds of up to 80 mph. The Bit Error

Rate (BER) of digital signals shall be greater than 1 in 1000. Performance shall be based upon use of handheld radios.

10. The system shall be provided with an AIMOS compatible System that permits remote interrogation and control of the equipment for the purposes of adjustment, diagnostics, and alarms .

11. Fiber Distributed Antenna Systems (Fiber DAS) or Bi-directional amplifiers (BDA) shall support the simultaneous flow of radio energy in uplink and downlink directions as follows:

    a. 806 to 809 MHz for uplink direction (handheld to base).

    b. 851 to 854 MHz for downlink direction (base to handheld).

12. The Radiating cable antenna system shall provide and support distribution of radio signals at levels sufficient to provide the radio performance described herein. Furnish RF budget calculations showing signal distribution and predicted performance throughout the facilities with stated coverage parameters. Splices and connectors shall be minimized.The fixings and supports touching the Radiax and within a 6-inch (150 mm) diameter from the center of the cable shall be non-metallic, low smoke zero halogen polymer, plastic or similar material. DC blocks shall be used to isolate between each BDA approximately 2000 feet Radiax sections.

13. Deployment of Radiating Cable

    a. In Tunnels:

        1) Two radiating cables, on the same side and 24 inches apart, shall be deployed along the length of each track, from tunnel portal to tunnel portal. The top cable shall be used for radio transmission (downlink), and the bottom cable for reception (uplink).

            a) The placement of the radiating cable shall be along each track and on the opposite side wall from the tunnel walkway, at a height 8 to 11 feet above the top of rail, but no lower than the top corner of the BART revenue vehicle. Six-inch edge to edge clearance will be provided around the radiating cable to other obstructions or infrastructure.

            b) The placement of the non-metallic, cable hanging, and hanger assemblies shall be in a straight line, consistently at the same tunnel position throughout the track environment. Alternative placement shall be permitted within the BART passenger station environment, such that the cable shall not be able to be touched by patrons.

            c) The cable system shall not encroach within the train car dynamic safety envelope.

            d) The cable shall not be placed in a manner that prevents its maintenance, or maintenance of adjacent equipment, or within 12 inches of tunnel lighting.

            e) It shall be up to the Designer to ascertain the proper radiating cable placement using these parameters.

2) Each track shall be provisioned with its own radiating cable. In underground areas that have more that two tracks and a common opening between tracks, two radiating cables, one cable on each outside side wall shall be deemed sufficient if radio calculations show adequate radio signal margin will be provided by this arrangement for all tracks.

3) Underground RF cable segments that interconnect adjacent amplifier equipment locations which are spaced more than 100 feet apart shall be provided with DC isolation.

4) The cable size shall be as large as required to minimize the attenuation loss in the cable for the spans as designed. The cable shall be optimized for radio signals from 400 MHz to 6000 MHz.

5) The cable jacket and hanging assemblies shall be of a low smoke, non-halogen design.

6) Connectors shall have weatherproof boots or wrappings, suitable for the installation environment, applied to them prior to placing the radiating cable system into service operation.

b. In Stations:

1) Radiating cable system deployed for the stations must provide coverage for the public including normal and emergency egress and secured areas of the station. They shall be located in areas where they cannot be touched or damaged by the public.

2) Free space antennas may be used if their coverage will provide equivalent coverage as the radiating cable.

B. Design Modifications and Additions Requirements:

Modifications or additions to the DAS Radio System shall satisfy the following general design principles:

1. It shall be designed and deployed in a manner so that no single point failure will render the radio coverage to the underground BART trackway environment inoperable. If a failure occurs, the redundant path equipment shall take over operation of the system and provide annunciation of the failure into the AIMOS.

2. Fully compatible with and become an integral part of the existing radio network.

3. Provide redundancy of system by separate RF sources, FIBER DAS equipment, and UPS batteries.

4. Unless otherwise specified, DAS shall be configured to operate up to 25 duplex 800 MHz NPSPAC radio channels simultaneously and in composite, without performance degradation below requirements.

5. DAS system additions shall be compatible with and provide the same functions and operability as the existing Fiber DAS (Commscope/Andrews) system. This includes the redundancy, remote network management (Commscope/Andrews AIMOS System) capability, and interface ports available to other BART radio systems. If upgrades to the existing BART DAS system equipment are required

to establish compatibility to the new equipment, then those upgrades shall become part of the Work.

2.02 SYSTEM REQUIREMENTS

A. The following are system interface requirements:

1. RF signals from Trunked Radio shall be applied to the DAS equipment by use of RF couplers installed in the transmit and receive coaxial cables to the site above ground antenna system. RF signals from mutual aid radio and the regional high-level radio shall be coupled directly from local base stations, installed in the above ground radio site, into a DAS RF port. RF signal levels shall be coordinated, and specified by the DAS manufacturer.

2. Data, and control signals to and from DAS equipment site shall interface with the existing EDACS and P25 control points radio equipment systems at Lake Merritt and shall also be configured to be compatible with the requirements of the BARTnet.

3. RF Coverage: The Fiber DAS shall provide radio coverage in a manner that provides radio signal strength between -90 dBm and -65 dBm, over 95 percent of the coverage area of BART trackway, public areas of BART passenger facilities, and other maintenance or operational facilities. Coverage area shall include the inside of BART revenue vehicles, while moving at speeds of up to 80 mph. The Bit Error Rate of digital signals shall not be greater than 1 in 1000. Performance shall be based upon use of handheld radios.

4. Redundant fiber optic cables shall be used to transfer the RF signals between tunnel portal section equipment and specific above ground radio site equipment.

5. Power to the amplifier nodes shall be –48 V DC. Unless otherwise noted, the power supply, batteries, charging, and telemetry circuits shall be provided by the DAS manufacturer. The 48 VDC UPS batteries shall be capable of providing normal operation for a period of eight hours after loss of AC power.

6. Newly proposed Fiber DAS radio redundant amplifier sites shall be located to provide at least primary and secondary system radio coverage. New transmit site facilities shall be located away from existing source of signal interference to limit or minimize degradation to the trunk radio system.

7. New site locations shall be placed upon District-owned property or projected-District-owned property along the right-of-way if possible. If the location of District property is not suitable for establishing radio coverage performance, then the designer shall attempt to find space in an existing and developed radio facility. Failing that, other off-site property locations may be proposed and evaluated.

PART 3 – EXECUTION

3.01 INSTALLATION

A. The Radio System elements and backup electric power housing shall be located adjacently.

B. Installation work shall be completed to the site-specific drawings and specifications.

3.02 SYSTEM OPTIMIZATION

A. Each Fiber DAS and RF Passive Distribution System shall be optimized for coverage and performance. Then it shall be integrated into the full BART Radio System, without any deterioration of service throughout any part of BARTs network.

3.03 FIELD TESTING

A. Work shall be performed to complete the testing set out in the test planning submittals, Contract Drawings, and Specifications.

B. Verify that the radio systems equipment has been installed in accordance with the Contract Specifications, Contract Drawings, and the system performance criteria. This shall include inspection, test and measurements of the DC power, ground tests, RF components sweep tests, the coverage maps, system configuration and attenuation settings on updated power block diagram, Radio Voice Quality DAQ, and BER testing. Record all test measurements. Provide diagrams showing equipment placement and routing for antennas, coaxial cables, and AC power to the District's Representative prior to acceptance testing. Power and network configuration settings shall be supplied with each test report. Submit an RF compliance certificate for each radio system at the conclusion of the acceptance testing.

3.04 TRAINING, MANUALS, SPARES AND SUPPORT

A. Full operating manuals and electronic documents shall be provided at each equipment location. Copies shall be provided to BART Engineering and Maintenance Departments.

B. Training shall be conducted by the original equipment manufacturer (OEM) or OEM partner engineering staff at BART premises for both engineering and maintenance engineers and technicians. Sufficient quantity shall be set up to allow staff from all shifts to complete training in small class sizes.

C. Spares shall be available for the Systems for 15 years from purchase, and if any components become unavailable, then OEM or OEM partners shall redesign replacements at their own cost, to keep equipment fully functional for this life-span.

D. OEM and OEM partners shall provide 24-hour support and support centers with knowledgeable tier 1 through 4 support staff available to support the systems for life of the product.

3.05 PREVENTATIVE MAINTENANCE SCHEDULES

A. OEM or OEM partner shall provide full preventative maintenance procedures and schedules for equipment and systems.

END OF SECTION 33 83 04

SECTION 33 83 05

RADIO NETWORK/REGIONAL HIGH LEVEL RADIO SYSTEM

PART 1 – GENERAL

1.01 SECTION INCLUDES

This Section covers the general approach for additions or modifications to the Regional High Level Radio System.

1.02 RELATED SECTIONS

A. 33 83 04, Trunked Radio Network/Distributed Amplifier Radiating Cable System

B. 33 83 06, Trunked Radio Network/Bi-directional Radio Amplifier System

1.03 MEASUREMENT AND PAYMENT

All work required under this Section will be measured separately and will be paid for as part of the Contract lump-sum price, as part of the related item of work, as indicated on the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. Federal Communications Commission (FCC):

1. FCC Rules and Regulations, Title 47 CFR, Telecommunications

B. National Public Safety Planning Advisory Committee (NPSPAC)

1. NPSPAC Northern California Region 6 Plan

C. Telecommunications Industry Association (TIA):

1. TIA Technical Systems Bulletin TSB 88-A

D. M/A-Com Incorporated:

1. Document AE/LZT 123 4618/1, Site Grounding and Lightning Protection

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit Shop Drawings showing the layout of the system identifying the location of equipment and accessories.

C. Product Data: Submit manufacturers' Product Data for manufactured items of materials, equipment, and accessories shown on the Shop Drawings.

D. Test Reports: Submit Test Reports of tests conducted by the Contractor.

E. Certificates: Submit Certificates certifying that the equipment tested is ready for use.

1.06 DESCRIPTION

The District owns and operates an 800 MHz radio network. Modifications to the radio network are anticipated over time due to refresh technologies and with expansion of the BART system. The Regional High Level (RHL) Radio System is one element of the BART radio network.

The RHL system is used for voice communications between Operations Control Center and trains when an area of the BART trunked system is out of service, or when BART Police officers or maintenance workers roam beyond the coverage area of the BART trunked system. It is a secondary and backup radio communication medium throughout the District, generally extending to the borders of those counties having BART facilities.

PART 2 – PRODUCTS

2.01 DESIGN

A. General

1. The Designer shall design and furnish modifications and additions to the RHL Radio System to satisfy design performance requirements. The existing RHL design shall be followed as guideposts for equipment selection, design, and their interconnections.

2. RHL Radio System coverage shall be made available above and below ground along the BART operating alignment, wayside facilities, and inside specific buildings as required. Coverage shall also extend to major freeways 15 miles from the edges of nearest BART facilities. Generally, coverage should be as extensive as possible. Coverage shall specifically include the out-of-doors areas of BART operating alignment and wayside facilities including the stations, yards and shops, operations control center, maintenance facilities, police zone facilities, administrative offices, and revenue processing facilities.

3. Though primarily an above ground system, the Designer shall include the equipment and designs necessary to furnish the RHL radio signals into the BART underground and specified buildings.

4. RHL Radio System design and equipment shall adhere to applicable codes and regulations, including Federal Communications Commission (FCC) Rules, and National Public Safety Planning Administration Committee (NPSPAC) Region 6

(Northern California) planning regulations for 800 MHz Public Safety Agencies. All transmitting equipment shall be FCC type certified.

B. Design Modifications and Additions Requirements:

Modifications or additions to the Regional High Level Radio System shall satisfy the following general design guidance:

1. Modifications or extension to the RHL Radio System design shall be fully compatible with and become an integral part of the existing radio network.

2. Unless otherwise noted, the RHL Radio System shall be designed to operate as a conventional, analog, GPS-coordinated simulcast system. It shall operate in the 800 MHz radio band, and upon the one duplex 800 MHz NPSPAC radio channel assigned to the District. CTCSS tones shall be provided for un-squelching the radio.

3. RHL Radio System modifications or additions shall be compatible with and provide the same functions and operability as the existing RHL radio system. This includes a remote network management capability, and interfaces to other elements of the BART Radio Network. If upgrades to any aspect of the existing BART Radio Network are required to establish compatibility or functionality to the new equipment, then those upgrades shall become part of the work.

4. If underground RHL radio coverage is necessary, low powered 800 MHz analog transmitters are to be added as described herein.

2.02 SYSTEM REQUIREMENTS

Modifications or additions to the RHL Radio System shall specifically satisfy the following requirements:

A. Performance Requirements:

1. The RHL radio system shall provide radio coverage outdoors and around areas along the BART track alignment and on the surface above tunnels and subways. With enhancement, the coverage shall extend inside BART wayside facilities including passenger stations, parking garages, train control and communications room, traction power substations, maintenance, yard and shops, revenue processing buildings, administration buildings, and other BART facilities supporting train operations, maintenance, administration, engineering, and police activities. Above ground coverage shall extend 15 miles in the direction of the alignment at the prescribed performance levels.

2. The system reliability performance goals of the RHL system shall be with 90 percent coverage at 90 percent of the time. The system shall be balanced between talk out and talk in directions. Coverage shall deliver performance deemed “clear with occasional background noise”, and as defined in TIA Standard TSB 88-A Delivered Audio Quality (DAQ) 3.4. Performance standards shall be based upon use of vehicle mounted mobile radios.

3. Unless otherwise specified, RHL coverage in underground trackway, stations, and facilities shall be made by a connection to the Distributed Amplifier System (DAS)–an underground amplifier system which is part of the BART radio network, and specified in Sections 33 83 04, Radio Network/Distributed Amplifier Radiating Cable System and 33 83 06, Radio Network/Bi-directional Radio Amplifier System. Performance and reliability goals of the RHL coverage deployed underground shall be governed by the DAS system.

    a. A low power, 800 MHz, analog radio transmitter/receiver shall be deployed to couple above ground RHL RF radio signals into the DAS underground. The low power transmitter shall be co-located with the primary trunked radio site feeding the BART underground areas and covered by the overlying RHL (mountain top) simulcast radio site. A second low power 800 MHz transmitter shall be deployed at a secondary trunked radio site of redundancy of radio coverage underground.

    b. Audio signals to the co-located trunked site low power RHL transmitter shall originate from the LMA Central Control equipment. Transmit audio shall come from the audio distribution buss equipment. Receive audio shall be applied to the RHL voter network. Modifications to this LMA equipment and transport of these signals to the co-located trunked site RHL transmitter shall be part of the design.

    c. Necessary interface port connections for the RHL connection to the DAS shall be provided by the DAS system. However, the proper RF signal levels applied to DAS are the responsibility of the RHL designer.

4. Unless otherwise specified, RHL coverage signal strength outside of surface BART facilities shall be sufficiently strong that a bidirectional amplifier can be deployed to extend the above ground RHL radio signals into the facility. The requirements for the bidirectional amplifier equipment are specified in Section 33 83 06, Trunked Radio Network/Bi-directional Radio Amplifier System.

5. RHL Radio System equipment shall be designed to operate in an environmentally controlled facility.

6. RHL Radio System equipment shall be housed in seismic zone 4 rated equipment cabinets, unless otherwise designated.

7. New RHL Radio System site equipment shall be designed anticipating that backup site power is by an automatic start generator-standby source, connected to an automatic transfer switch. The equipment shall be capable of riding thru the loss of power for a minimum of 15 seconds without loss of operation, unless otherwise designated.

8. All antenna entrances to the RHL radio equipment facility shall be protected against lightning strikes.

B. System Interface Requirements

1. Audio, data, and control signals to and from each newly proposed transmit site shall interface with the existing Enhanced Digital Access Communications

System (EDACS™) control point radio equipment at Lake Merritt and shall also be configured to be compatible with the requirements of the BARTnet.

2. Below ground radio coverage shall be provided to subway stations and tunnel areas, and shall be designed to interface with the radio network equipment in a manner similar to that of the existing below ground radio communication equipment throughout the District. Typically, fiber optic cables are used to transfer the RF signal between tunnel portal section equipment and specific above ground radio site equipment. An interface to the underground Distributed Amplifier Radiating Cable System (DAS) equipment at the trunk radio site shall be anticipated in system design.

3. The District shall be responsible for licensing of RHL system. The Designer shall provide the District with requested technical information, including any predictive coverage and performance maps, descriptions, and reports.

4. The Designer shall furnish other support that may be necessary to obtain licensing approval from agencies in the licensing process.

C. Radio System Site Locations:

1. If new radio sites are required, such radio sites shall be located to obtain the specified system radio coverage and reliability percentages.

2. RHL radio site locations shall be evaluated to be placed on developed radio sites, typically on a mountain top, adjacent to the area where coverage is required.

3. If a suitable location cannot be found among developed radio sites, other off-site property locations may be evaluated. Suitability of the site shall be determined by RF coverage predications, commercial availability of the site, and site access cost; and ranked in order of design preference.

4. An RF Coverage assessment to evaluate proposed extension to existing RHL Radio System coverage shall be conducted as part of the design planning.

   a. Assessment shall consist of two parts:

      1) The first part is a computer generated mapping showing predicted radio performance from each proposed radio site, as well as a composite model of all sites.

      2) The second part is a drive test to verify real world performance of the computer modeling predictions of the selected site location. Signal strength, urban clutter, simulcast time domain interference over the BART right of way are minimally required in the computer prediction.

   b. Existing system coverage modifications, if required, shall be developed and shown in the predictive mapping of extension sites.

   c. A performance guarantee from the manufacturer/designer shall accompany the RF Coverage assessment.

5. New RHL transmitter site equipment shall be designed and provisioned to limit or minimize performance degradation to the radio system from foreign sources.

D. Dispatcher Console Equipment

Control over the RHL radio system shall be accomplished by the C3 Maestro Console system, as manufactured by MACOM Inc[AE1]. The system shall interface to the existing EDACS™ control point radio equipment at Lake Merritt. Necessary interface to the control point equipment shall be provided as a part of the RHL system.

PART 3 – EXECUTION

NOT USED

END OF SECTION 33 83 05

SECTION 33 83 06

RADIO NETWORK / BIDIRECTIONAL RADIO AMPLIFIER SYSTEM

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Bi-directional Radio Amplifier (BDA) System

B. Installation and field testing.

1.02 MEASUREMENT AND PAYMENT

Separate measurement and payment will not be made for work required under this Section. All costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work of this Contract.

1.03 REFERENCES

A. Codes and Orders: The design of all equipment and materials shall conform to the following codes and orders:

1. National Electrical Safety Code (NESC)

2. California Electrical Code (CEC)

B. Rules, Regulations and Plans:

1. FCC Rules and Regulations 47 CFR.

2. NPSPAC (National Public Safety Planning Advisory Committee) Requirements for 12.5 kHz off-set frequencies, Northern California Region 6 NPSPAC Plan.

C. Standards: The following standards shall apply to the design work, and are hereby made a part of these Specifications to the extent referenced:

1. Telecommunications Industry Association (TIA)
Technical Systems Bulletin TSB 88-A

1.04 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data and Samples, for submittal requirements and procedures.

B. Drawings: Submit detail drawings including panel and cabinet layouts, equipment interconnection diagrams, equipment and material lists, manufacturer's descriptive and technical literature, catalog cuts, and installation instructions.

C. Instructions: Where installation procedures, or any part thereof, are required to be in accordance with the recommendations of the manufacturer of the material being installed, submit printed copies of these recommendations for approval prior to installation.

D. Design: Submit design information as required for review and approval. If requested by the Engineer, a Design Review Meeting shall be held in a District facility for the Contractor to present the design submittal.

1.05 EXISTING TRUNKED RADIO SYSTEM DESCRIPTION

A. The existing above ground trunked radio system is a 10 channel Enhanced Digital Access Communications System (EDACS™) simulcast system, as manufactured by M/A-Com.

B. The radio system is designed to provide clear, intelligible communication from portable radios with area coverage reliability of 95% or better. In some locations, radio signal penetration into wayside facilities is insufficient to provide this level of communication performance. The provision of a Bi-directional Radio Amplifier (BDA) system within such a facility corrects for this condition.

PART 2 – PRODUCTS

2.01 GENERAL

A. The BDA system shall be designed and furnished to operate in the 800 MHz band, specifically on 821-824 MHz /866-869 MHz. It shall be also capable of operation at 806-809 Mhz /851-853 Mhz, reaching these frequencies by readjustment only, without component change.

B. The BDA system shall be designed to provide a minimum -90 dBm RF signal level, or a minimum of 10 dB above the RF noise floor, at any point within the building, or elsewhere as designated in the specifications or Contract Drawings.

C. The BDA RF output shall not be close-coupled to the RF input so as to prevent feedback saturation. The minimum output-to-input path loss shall equal the maximum operating gain of the amplifier plus 10 dB. For example, a BDA with 55 dB overall maximum gain shall have minimum of 65dB input-to-output isolation. System component selection and layout shall take this requirement into consideration when placing the BDA system components in and around the building.

D. The BDA system shall be capable of accurately and properly amplifying and distributing radio signals without causing any sort of radio system degradation. It shall be capable of using the following modulation techniques and formats:

1. Analog FM

2. Digital FM

3. EDACS™
4. TDMA
5. CDMA
6. P25 Phase II
7. GSM

E. The BDA system shall be FCC type-accepted, and labeled as such prior to placing it into operation.

2.02 BI-DIRECTIONAL AMPLIFIER

A. The BDA shall be an automatic gain adjusting or OLC (output level control) type, where the gain is automatically set over a wide operating range. The BDA system shall be FCC type accepted, and labeled as such prior to placing it into operation.

B. An input signal level of -60 dBm is the nominal input signal level applied into the BDA system. The Contractor shall take steps to augment local input signal reception to this level. Less input signal might cause the BDA system to operate at a reduced output signal level. If the Contractor cannot make the input level reach the nominal level, the Contractor shall notify the Engineer, and provide the expected input signal level, and corresponding output level as part of the design submittal.

C. The BDA system shall amplify all signals within the specified frequency band. The effective output power per channel is reduced as more channels are amplified. The Contractor must account for the reduction in signal strength when calculating the signal distribution within the building. The following table depicts the typical effect of multiple channel amplification.

Number Of Frequencies In The Passband	Maximum Output Power Per Single Channel
2	24.7 dBm
4	20.0 dBm
6	17.5 dBm
8	15.5 dBm
10	14.1 dBm
20	9.8 dBm

D. The maximum output power of the amplifier shall be set below the amplifier's 1 dB compression point to prevent damage to the amplifier and minimize signal distortion. If necessary, external attenuator pads shall be inserted before the electronic attenuator to prevent overdriving the BDA OLC circuitry.

E. Decoupled RF test points shall be provided to permit performance testing or alignment while the BDA is in operation. They shall be clearly labeled as test points, and depicted on a block diagram with the rest of the BDA circuitry.

F. The BDA system shall be powered by the building's electrical distribution system. A transient voltage surge suppressor shall be provided as part of the bidirectional amplifier design, and protect the incoming power line from transients.

G. If shown on the Contract Drawings, a backup electrical power supply shall be provided for the BDA system. It shall be designed to permit a minimum of four hours of BDA operation. If a battery supply is used as backup, a power supply shall be furnished to maintain the batteries at the manufacturer's recommended float level and shall also recharge the batteries should the charge be depleted. Alternatively, the backup power may be provided from an existing building UPS and/or generator system.

H. The BDA unit shall be furnished in a wall mounted NEMA 4 cabinet. The cabinet shall have a front door that is provided with either a locking handle or lock hasp. Adequate space inside the cabinet shall be provided for servicing the unit. The unit shall be labeled with an exterior nameplate stating "Radio Amplifier". Internal components shall be identified with labels.

I. If installed outdoors or unprotected locations, the cabinet shall be weatherproof stainless steel NEMA 4. All penetrations into the cabinet shall be made with RGS or IMC conduit, and weatherproofed.

2.03 EXTERIOR ANTENNA SYSTEM

A. The exterior antenna system shall consist of a highly directional gain antenna, an antenna mount, coaxial lightning surge suppressor, and a minimum 1/2" type LDF coaxial cable feed to the BDA. The specific size of the feed line coaxial cable shall depend on the system design. A short super flexible cable may be used to connect the antenna to the RF feed line cable. The exterior antenna shall be configured to mount on or near the building rooftop, at a location affording the best view towards the nearest radio repeater site. The antenna shall be oriented towards the nearest system repeater site. If requested, the District will provide the antenna orientation. The antenna gain shall be selected to provide the minimum required signal level.

B. A lightning surge suppressor shall be connected in the RF coaxial feed line in-between the antenna and the BDA. The coaxial lightning surge suppressor shall be Polyphaser Model IS-50NX-C2 or equal, 50 ohm, N-Female termination, flange mounted. A copper grounding plate shall be provided with the surge suppressor, and bonded to the grounding system. If the BDA is mounted inside a building, the surge suppressor will be installed inside that building at the cable penetration point. Building penetration for RF feed line cabling shall be protected with a waterproof/UV stabilized cable boot suitable for the installation, or with an electrical service weatherhead and coaxial cable drip loop.

C. The antenna system, antenna mast, coaxial cable, and surge suppressor shall be grounded by attachment to the building's grounding system. If necessary, a new ground rod shall be driven to provide a grounding path for the antenna system to

earth. The coaxial cable shall be connected to the ground system by means of the cable manufacturer's shield grounding kit. A Ground system connection to the coaxial cable shall be at either end of exterior-run coaxial cable if it exceeds 100 feet in length, otherwise within 20 feet of building entrance. The coaxial lightning surge suppressor shall be grounded per the manufacturer's recommendations. Grounding cable shall be sized according manufacturer's recommendations.

D. The antenna installation shall be suitable for operation with wind loading of 80 mph in no ice conditions. All components shall be suitable for outdoor installation. All outdoor RF connections and coaxial cable grounding kits shall be covered in weatherproof connector boot coverings.

2.04 IN-BUILDING ANTENNA SYSTEM

A. The in-building antenna system shall consist of a sufficient number of antennas and/ or radiating cable distributed within the building to meet the -90 dBm, or 10 dB above noise floor, design criteria throughout the building. Coaxial power dividers shall distribute and balance the radio signals into appropriate branch circuits connecting back to the BDA. A RF link budget shall be developed and submitted as part of the design submittal to show the distribution of signals throughout the cabling system.

B. The coaxial cable shall be a minimum of ½" type foam dielectric low loss type and shall be installed as depicted in the Contract Drawings. Radiating coaxial cable shall be minimum of ⅞" foam dielectric, and shall be installed a minimum of 2 inches off of any wall surface. Cable jackets for any coaxial cables installed indoors shall be low smoke, non-halogen construction. Attachment between the cable and building shall be by plastic cable clamps, expressly designed for the application.

C. Each splitter shall be mounted in a separate junction box located so as to be easily accessible for maintenance while maintaining security from unauthorized tampering. Each junction box shall be labeled externally.

PART 3 – EXECUTION

3.01 INSTALLATION

A. The BDA and backup electric power housing shall be wall mounted side by side. The equipment room where the BDA is mounted must have access to the building halo or electrical ground system and shall be well ventilated. Maximum ambient temperature of the mounting location shall be 30°Ct. An electric circuit breaker panel with two, 120 VAC, 20 amp branch circuits shall be installed in the equipment room to service the BDA unit and backup power supply. All exterior coaxial cable shall be installed in 2-inch conduit.

B. If RF distribution requires, a junction box shall be installed in the equipment room and every two floors below the equipment room with a box terminating in the lowest level of the building. The roof end of the conduit must extend two feet above the roof deck and be terminated with an electrical wire head.

3.02 SYSTEM OPTIMIZATION

A. The BDA shall be adjusted to the level of desired signal and avoid inter-modulation. Fixed attenuators may be used to set the BDA levels if required.

B. The BDA's OLC circuits shall provide a dynamic range of 30 to 40 dB. If the input level to the BDA causes continual output limiting, a fixed value coaxial RF attenuator shall be inserted at a point provided in the BDA's input circuit.

3.03 FIELD TESTING

A. Perform all work necessary to plan, schedule, and conduct tests, and to complete the required documentation as specified in the Contract.

B. Verify that the BDA system has been installed in accordance with these specifications, the Contract Drawings and the system performance criteria. This includes inspection, test and measurements of the D.C. power, the BDA gain, and the signal levels within and outside of the building. Record all test measurements. Provide diagrams showing equipment placement and routing for antennas, coaxial cables and AC power to the District's Representative prior to acceptance testing. Submit an RF Compliance Certificate for each BDA system at the conclusion of the acceptance testing.

END OF SECTION 33 83 06

SECTION 33 83 07

RADIO NETWORK / MUTUAL AID RADIO SYSTEM

PART 1 – GENERAL

1.01 SECTION INCLUDES

This Section covers the general approach for the design of the Mutual Aid Radio System.

1.02 RELATED SECTIONS:

A. 33 83 04, Trunked Radio Network / Distributed Amplifier Radiating Cable System

1.03 MEASUREMENT AND PAYMENT

All work required under this Section will be measured separately and will be paid for as part of the Contract lump-sum price, as part of the related item of work, as indicated on the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. Federal Communications Commission (FCC) Rules

Code of Federal Regulations, 47 CFR

B. National Public Safety Planning Administration Committee (NPSPAC)

Region 6 (Northern California) planning regulations for 800 MHz Public Safety Agencies

C. M/A-Com Incorporated:

Document AE/LZT 123 4618/1, Site Grounding and Lightning Protection

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit Shop Drawings showing the layout of the system identifying the location of equipment and accessories.

C. Product Data: Submit manufacturers' Product Data for all manufactured items of materials, equipment, and accessories shown on the Shop Drawings.

D. Test Reports: Submit Test Reports of all tests conducted by the Contractor.

E. Certificates: Submit Certificates certifying that the equipment tested is ready for use.

1.06 DESCRIPTION

The Mutual Aid Radio System provides radio communications for inter-agency police, fire, and other emergency operations in BART tunnels, subways and underground passenger stations.

PART 2 – PRODUCTS

2.01 DESIGN

A. General

1. A conventional, analog 800 mhz NPSPAC radio system for mutual aid purposes shall be furnished to provide radio communications coverage in the underground portions of the BART system. As such, it will connect to the Distributed antenna radiating cable system (DAS) that provides radio signal distribution throughout the BART underground area.

2. The RF coverage requirement is for the below ground only, and shall include the trackway, passenger stations, power facilities, ventilation buildings, and emergency passageways within the BART underground. Direct RF radiation above ground, or leakage of RF signals into the above ground environment is to be avoided.

3. For system redundancy, two transmitters for the mutual aid radio system shall be equipped at each tunnel portal. They shall operate on be the existing State designated and licensed frequencies.

4. System design shall permit simultaneous operation of and not cause interference or degradation to the Simulcast Enhanced Digital Access Communication System (EDACS) Trunk Radio Communication System used throughout the District, or any other radio communication systems in use.

5. Mutual Aid Radio System design and equipment shall adhere to applicable codes and regulations, including Federal Communications Commission (FCC) Rules, and National Public Safety Planning Administration Committee (NPSPAC) Region 6 (Northern California) planning regulations for 800 MHz Public Safety Agencies. All transmitting equipment shall be FCC type certified.

6. The mutual aid radio system to be provided shall be compatible with and provide the same functions and operability as the existing mutual aid radio system. A remote network management capability shall also be included

7. The planning for any extension to the system shall include an RF Coverage assessment to evaluate the impact of such an extension to the existing radio systems in use within the BART underground. All necessary modifications to existing systems shall be implemented to integrate the new extension

B. Design Modifications and Additions Requirements:

Modifications or additions to the Mutual Aid Radio System shall satisfy the following general design guidance:

1. Modifications or extension to the Mutual Aid Radio System design shall be fully compatible with and become an integral part of the existing radio network.

2. Unless otherwise specified, the Mutual Aid Radio System shall be designed to operate as a conventional, analog. It shall operate in the 800 Mhz radio band, and upon each of the two duplex 800 Mhz NPSPAC radio channels assigned to the State. CTCSS tones shall be provided for unsquelching the radio.

3. Mutual Aid Radio System modifications or additions shall be compatible with and provide the same functions and operability as the existing Mutual Aid radio system. This includes a remote network management capability, redundancy, and interfaces to other elements of the BART Radio Network. If upgrades to any aspect of the existing BART Radio Network are required to establish compatibility or functionality to the new equipment, then those upgrades shall become part of the work.

2.02 SYSTEM REQUIREMENTS

A. General

1. The Mutual Aid Radio System shall be designed for operations on 2 separate channels. Each channel shall be separately equipped. The channels shall be as designated by BART.

2. The Mutual Aid Radio system shall connect to the BART underground Distributed Antenna System to provide radio coverage inside and around all areas along the underground tunnels and subways and stations. This coverage shall be based upon handheld radio performance. All necessary interfaces shall be provided for proper operation and control. The Contractor as a part of this specification shall make modifications to the Distributed Antenna System necessary to add the Mutual Aid Radio System operation.

3. The system reliability shall be with 95% coverage at 95% of the time. All coverage shall deliver performance deemed “loud and clear with occasional background noise” also known as circuit of merit level CM4.

B. System Interface Requirements

1. Audio, data, and control signals to and from each newly proposed transmit site shall interface with the existing EDACS control point radio equipment at Lake Merritt and shall also be configured to be compatible with the requirements of the BARTnet.

2. Dispatch consoles shall be configured to operate and control the Mutual Aid Radio system.

3. Any proposed Mutual Aid Conventional channel shall be compatible with the existing High Level simulcast system, and shall interface with the conventional high-level control point equipment at Lake Merritt.

C. Radio System Site Locations:

1. Newly proposed transmit sites shall be located to obtain the specified system radio coverage and reliability percentages. New transmit site facilities shall be located away from existing source of signal interference to limit or minimize degradation to the trunk radio system.

2. The trunk radio T1 interface signal connections between the transmit site equipment and the control point equipment shall be made in accordance with the requirements of BARTnet.

3. Below ground radio coverage shall be provided to all subway stations and tunnel areas, and shall interface with the control point equipment similar to the existing below ground radio communication equipment throughout the District. Typically fiber optic to tunnel conversion equipment and fiber optic to trunk radio conversion equipment are used to transfer the RF signal between tunnel equipment and above ground equipment. Along each subway track a radiating coaxial cable shall be used as the primary antenna for below ground radio transmission (downlink) and reception (uplink). This antenna system and all of its components shall be provided and installed to be compatible with the existing utilized Andrews Corporation communication portion of the trunk radio system.

   a. Unless otherwise specified, Mutual Aid coverage in underground trackway, stations, and facilities shall be made by a connection to the Distributed Amplifier System (DAS), an underground amplifier system which is part of the BART radio network, as specified in Sections 33 83 04, Radio Network / Distributed Amplifier Radiating Cable System. Performance and reliability goals of the Mutual Aid coverage deployed underground shall be governed by the DAS system.

      1) Two low power, 800 mhz, analog radio transmitter/receiver shall be deployed to couple above ground Mutual Aid RF radio signals into the DAS underground. The transmitter shall be co-located with the trunked radio site feeding the BART underground areas covered by the overlying Mutual Aid (mountain top) simulcast radio site.

      2) System design shall be provided in a redundant manner (second set of transmitter equipment) in cases where the tunnel length exceeds 1500 feet.

      3) Audio signals to the co-located trunked site Mutual Aid transmitter shall originate from the LMA Central Control equipment. Transmit audio shall come from the audio distribution buss equipment. Receive audio shall be applied to the Mutual Aid voter network. Modifications to this LMA equipment and transport of these signals to the co-located trunked site Mutual Aid transmitter shall be part of the design.

      4) Necessary interface port connections for the Mutual Aid connection to the DAS shall be provided by the DAS system. However, the proper RF

signal levels applied to DAS are the responsibility of the Mutual Aid designer.

PART 3 – EXECUTION

NOT USED

END OF SECTION 33 83 07

SECTION 34 05 17

COMMON WORK RESULTS FOR TRACKWAY

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. District-furnished materials.

B. Contractor-furnished materials.

C. Construction equipment.

D. Track tools.

E. Track alignment and geometry.

F. Track markers.

G. Thermal rail adjustment.

H. Track tolerances.

I. Contractor geometry inspection.

J. Track inspections.

K. Contract rail insulators.

L. Third rail rust and mill scale removal.

M. Trackway drainage.

1.02 RELATED SECTIONS

A. Section 34 11 23, Special Trackwork

B. Section 34 11 24, Direct Fixation Track

C. Section 34 11 25, Running Rail

D. Section 34 11 27, Ballasted Track

E. Section 34 11 30, Embedded Track

F. Section 34 11 31, Concrete Ties

G. Section 34 11 32, Resilient Ties

H. Section 34 11 37, Direct Fixation Fasteners

I. Section 34 11 93, Track Appurtenances and Accessories

1.03 MEASUREMENT AND PAYMENT

A. General Track Construction will not be measured separately for payment. All costs in connection therewith will be considered as included in the applicable Contract lump sum price or the Contract unit price per linear foot for trackwork of the different types indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. American Railway Engineering and Maintenance of Way Association (AREMA).

1. AREMA Manual.

B. Association of American Railroads (AAR).

1. AAR Section G, Wheels and Axles.

C. Code of Federal Regulations (CFR).

1. Title 49, Environment, Volume 4, Chapter II, Federal Railroad Administration, Department of Transportation.

D. State of California, Department of Transportation (Caltrans), Standard Specifications, Section 95, Epoxy.

1.05 SUBMITTALS

A. Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Provide additional submittals as required herein.

C. All submittal shall be prepared, reviewed, signed, and sealed by a qualified independent California Registered Professional Engineer, experienced in the design of the item being submitted.

D. Submit design drawings, material specifications, laboratory test results, and fabrication procedures in sufficient detail to demonstrate conformance or equivalence with the Contract requirements herein.

E. Any requests for deviation from Contract requirements shall be submitted separately and in advance of the submittals required herein.

F. Submittals shall include all approved requests for deviation from the Contract requirements. No unapproved requests for deviation shall be included with the submittal.

G. Submittals for each item shall be submitted as a complete package and include all required information. No external references are allowed; all required information shall be included with the submittal.

H. Each submittal shall include a certification, prepared by the qualified independent California Registered Professional Engineer, that information in the submittal meets all applicable Contract requirements.

I. Quality Control Plan: Submit for approval prior to beginning track construction a detailed quality control plan for ballasted, direct fixation (DF), resilient tie (RT), embedded track and special trackwork that includes all corrective procedures.

J. Construction Equipment Submittals:

1. Submit loading diagrams for all construction equipment and complete calculations, showing conformance with indicated live load requirements for approval before construction equipment will be permitted on ballast deck bridges or aerial structures.

2. Submit construction equipment data for all on-track construction equipment, showing compliance with wheel contour, gage, and clearance requirements.

K. Test Reports: Submit laboratory reports certifying that track gages, levels, and torque wrenches are within specified accuracy tolerances.

L. Track Inspection Reports: Submit two copies of all track inspection reports including charts, continuously covering tracks inspected, at least two weeks prior to any Substantial Completion inspections.

M. Pre-Operations Trackway Inspection Reports: Submit a written copy of all the inspection reports, with a cover sheet clearly defining the areas, tracks, and special trackwork inspected immediately prior to vehicle operations. The cover sheet shall specifically state if the inspected area(s) are safe for vehicle operations.

N. Drainage Systems Video Inspections: Submit video recording of the lines inspected in an electronic format such as compact discs or tape suitable for viewing on standard equipment commercially available, at least two weeks prior to any Substantial Completion inspections. Other formats may be used with prior written approval of the Engineer.

O. Personnel Qualifications: The qualification of the persons(s) performing the pre-operations trackway inspections shall be submitted for approval to the District, at least two weeks in advance of that person(s) performing any inspections.

1.06 QUALITY ASSURANCE

A. Refer to Section 01 43 00, Quality Assurance, and Section 01 45 00, Quality Control, for general requirements and procedures.

B. Inspections:

1. All work will be subject to inspection by the Engineer, at the place of manufacture, at the shipping point, and at the shipping destination.

2. Material found to be defective, damaged, or otherwise non-conforming shall be tagged or otherwise marked by the manufacturer and shall be segregated from the material to be provided under the Contract. Such material shall not be repaired or remanufactured without the written approval, in advance, of the Engineer.

3. The Contractor shall be responsible to ensure that all material meets all requirements, as described herein, upon completion of the Work. Any materials damaged during manufacture, shipping, handling, construction, installation, testing and inspection shall be replaced.

C. Except for modifications, amplifications, deletions, and additions indicated herein, construct track in accordance with the requirements of the AREMA Manual.

1.07 QUALIFICATIONS

A. Supervisory Personnel: Track construction shall be performed under the direction of qualified and competent supervisory personnel, including foreman and gang leaders, experienced in track construction.

B. Pre-Operations Trackway Inspections: The person(s) performing the inspection shall meet the requirements provided in the CFR Title 49, Part 214 (FRA Standards), Subpart A, Article 213.7(b). Minimum qualification shall be based upon experience inspecting operational tracks, with the inspection made under traffic.

1.08 GEOMETRIC DATA

A. Layout tracks to the detailed horizontal and vertical alignment data indicated on the line Contract Alignment Drawings and Plan/Profile Drawings.

B. Key alignment and profile data is indicated on the track charts and is for general orientation only.

PART 2 – PRODUCTS

2.01 DISTRICT-FURNISHED MATERIALS

A. Refer to Section 01 64 13, District-Furnished Materials and Equipment, of the Contract Specifications for description and quantity of District-furnished materials.

2.02 CONTRACTOR-FURNISHED MATERIALS

A. All products, tools, materials, equipment and labor required to complete all aspects of the work shall be furnished by the Contractor including construction equipment and materials to perform the work required to repair and correct track deviations that

exceed specified tolerances disclosed by the specified inspections, and subsequent re-inspections.

B. Inspection Devices: The Contractor shall furnish to the District, the following items in the quantities indicated for the District's use in inspecting trackwork. The items shall be provided prior to beginning track construction and shall become the property of the District.

1. Four rail thermometers identical to those to be used by the Contractor, and conforming to AREMA. The rail thermometers shall be identical to those to be used by the Contractor.

2. Four track level/gages, Sola Model ULM-G, 66 inch, modified for BART 5 foot 6 inch track gage, “English” graduations. Track level/gage is a Designated Matching Product.

3. One Sola Platform Clearance Gage, modified for 5 foot 6 inch track gage, “English” graduations. Platform Clearance Gage is a Designated Matching Product.

4. Four 36-inch aluminum straightedges, two 72-inch aluminum straightedges.

5. Four taper gages, graduated in thousands of an inch.

6. Two curve paddles with stringline and measuring rule.

7. One spot board.

8. Two torque wrenches of the correct torque range, with the correct size sockets for all nuts and bolts required in the work, and a 9 inch socket extension.

C. Paint for Civil Data: The paint shall be a two-part linear polyurethane applied in accordance with the manufacturer’s instructions.

PART 3 – EXECUTION

3.01 CONSTRUCTION EQUIPMENT

A. Contractor's on-track construction equipment shall be designed and constructed to operate within the clearances indicated.

B. The equipment shall be capable of operating on BART’s 66 inch gage track.

C. Wheel contours for on-track construction equipment shall conform to AAR standard wheel or AREMA maintenance-of-way work equipment wheels.

D. Single wheel live loads shall not exceed 16,000 pounds uniformly distributed over an area of one square foot applied at any point on BART standard or special aerial structures.

3.02 TRACK TOOLS

A. Except otherwise provided herein, all tools shall conform to AREMA “Specifications and Plans for Track Tools” modified for 5 foot 6 inch track gage.

B. Gages and track levels shall be tested for accuracy by an approved testing laboratory prior to being used for the Work. The Contractor shall submit laboratory reports certifying that the device is accurate to within 1/32” of any measurement.

C. Torque wrenches shall be tested for accuracy by an approved testing laboratory prior to being used for the Work. The Contractor shall submit laboratory reports certifying that torque wrenches are accurate to within one percent of any measurement.

D. All measuring tools shall be calibrated prior to use and as often as necessary during use to ensure accurate measurements.

3.03 TRACK ALIGNMENT AND GEOMETRY

A. Requirements: Construct trackwork to the horizontal alignment and vertical profile indicated, and within the tolerances specified in Table 1 and Table 2 and as provided herein.

B. Profile Rail: The Contractor shall designate right or left rail, while facing in the direction of increasing stationing, to control the elevation of all tangent tracks on a Contract-wide basis. The inside or low rail on curves shall be the profile rail. Top of rail elevations and profile data shall be given for the referenced track. Where another track is parallel or nearly parallel to the referenced track and does not have a profile given, the elevations shall also apply to that track. Elevation transfer shall be at right angles to the referenced track or, on curves or spirals, radial to the referenced track.

C. Line Rail: The Contractor shall designate right or left rail, while facing in the direction of increasing stationing, to control the alignment of all tangent tracks, and the high or outside rail on horizontal curves as line rail on a Contract-wide basis. The line rail shall be located 2 feet 9 inches, measured horizontally, from the design centerline of track indicated on the alignment drawings included with the Contract Drawings.

3.04 TRACK MARKERS

A. Location Accuracy

1. Track marker locations shall be located and confirmed by a professional land surveyor or civil engineer currently licensed or registered in the State of California.

2. Track markers shall be installed and their locations confirmed prior to any inspections.

3. Track markers shall be maintained by the Contractor, until all Contract exceptions are repaired.

B. Superelevation Tags

1. Tags shall be 20-gage aluminum sheet with raised embossed numbers 3/4 inch in height.

2. Install at locations for each 1/4 inch increment of superelevation, starting at 0 inches, on all horizontal curves, including those with 0 inch superelevation, except closure curves within turnouts.

3. Install with epoxy adhesive in accordance with Caltrans Standard Specifications Section 95-2.05, approximately 12 inches inside the high rail to read in the direction of increasing stationing.

4. Tags shall be installed as follows:

   a. Ballasted track: On the tops of the ties.

   b. Direct fixation track: On the second pour concrete, at the same level as the bottom of the direct fixation pad assemblies.

   c. Resilient Tie Track: On the tops of the resilient ties.

   d. Embedded track: Superelevation tags are not required on embedded track.

C. Painting of Civil Data on Rails

1. The following civil data shall be painted on the rail, as provided herein:

   a. At all points of change of horizontal and vertical alignment.

   b. At all stationing equations.

   c. Stationing shall be provided every 100 feet, all even stations.

   d. Where conflicts exist between different civil data, the arrows for both shall be shown; all of the lettering and numbering shall be located to one side of the related arrow, without interfering with the adjacent arrow.

   e. Where crossing material hides painted data, the data shall be painted as near as possible to the running rail, on the surface of the crossing.

   f. Within turnouts, the data shall be shown on the rails for both tracks.

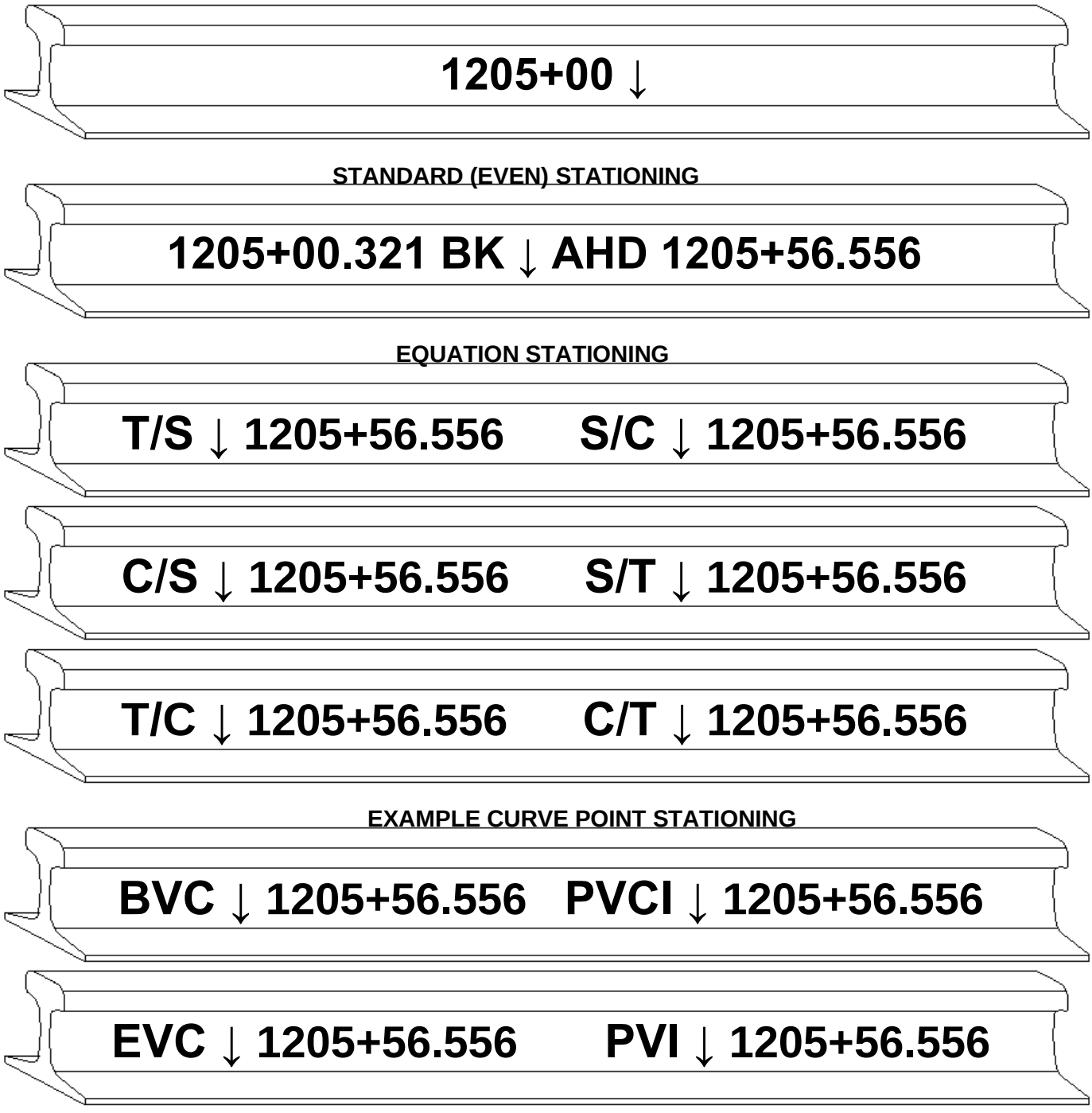
2. Data shall be located on every track on the rail opposite the adjacent walkway. Where no walkway exists, data shall be located on the rail opposite of the adjacent track with the greatest track centers.

3. At locations where the data changes to the opposite rail, it shall be shown on both rails.

4. Prior to painting, oil and grease shall be removed by solvent cleaning, vapor degreasing, or steam cleaning.

5. Stationing and letters as required shall be Romanex Text, white in color, and 3 inches high, on a black background. Letter line width shall be between 3/8 and 1/2 inch. The black background shall be continuous and extend 1/2 inch beyond the edge of all lettering. Refer to Figure 1, herein.

FIGURE 1 - PAINTING OF CIVIL ALIGNMENT DATA ON RAILS



Note: All examples are shown for increasing stationing from left to right, when facing the gage side of the running rail. These shall be reversed when stationing decreases from left to right when facing the gage side of the running rail.

3.05 THERMAL RAIL ADJUSTMENT

A. The final installation of continuously welded rail (CWR) shall provide a uniform neutral rail temperature of plus or minus 5 Fahrenheit degrees of the temperatures provided herein.

B. Adjacent CWR shall provide a uniform neutral rail temperature of plus or minus 5 Fahrenheit degrees of each other.

C. Initial rail temperature shall be determined by means of a standard AREMA rail thermometer. Temperature of rail shall be determined by placing the rail thermometer on the underside and along the centerline of the rail base and left in place until no change in its reading is detected.

D. The neutral rail temperature (t) used shall be as follows:

1. t = 120 degrees Fahrenheit: C Line North of Mile Post 7.8 and A, L and S Lines South of Mile Post 6.0.

2. t = 110 degrees Fahrenheit: R Line and Concord Line South of Mile Post 7.8, Alameda Lines North of Mile Post 6.0 and M Line North of Mile Post 2.8.

3. t = 100 degrees Fahrenheit: M and W Lines South of Mile Post 2.8.

4. t = 80 degrees Fahrenheit: All locations, in subway areas greater than 1000 feet in length and more than 500 feet away from portals.

E. Install a temporary joint to align the rail ends, set the required gap, and support a dutchman rail section to prevent damage to rail ends due to operation of rail mounted track equipment. Use a dutchman if the gap is greater than 1/2 inch.

F. Rail movement shall be exclusively used to determine when rail anchoring is required.

G. The method used to thermally adjust CWR shall not damage any portion of the track or other devices in the trackway.

H. Final adjustment and anchorage of rail shall not be done until the surface and alignment of the track has been placed to within 1/2 inch of design and all ballasting and stabilization have been completed. Surface and alignment found to be more than 1/2 inch of design shall be cut and readjusted after the surface has been repaired.

I. Where connecting to existing tracks the existing rail shall be readjusted for 500 feet, or up to any special trackwork, in both directions from the joint.

J. If for any reason the rail is cut after thermal adjustment is made, or where cutting in to existing track, the rail must be readjusted for 500 feet, or up to any special trackwork, in both directions from the cut. Any incorrect thermal rail adjustment shall be readjusted.

K. Installing CWR on Direct Fixation or Resilient Tie Track: In addition to the other requirements herein, CWR shall be installed on direct fixation or resilient tie track in accordance with the following requirements.

1. On aerial, structure CWR shall be installed to be continuous between abutments where the strings are anchored by concrete tie rail fasteners on the adjacent at-grade track.

2. Install CWR on aerial structures and in subways with neither structure nor track subjected to excessive forces imposed by temperature changes or other forces.

3. Anchor CWR on standard aerial structure within the following limitations.

    a. The anchoring of one, two, three, or four rails may advance together if the rail thermal force is uniform within the limits of plus or minus 10 degrees Fahrenheit of the average rail temperature of the track region as specified herein.

    b. If the anchoring operation is interrupted for more than three hours, the operation on each rail shall be staggered at least five girder lengths from the operation on any other rail supported by the same structure.

4. On aerial structures, if the CWR adjustment is by rail stretching, then perform the following operations.

    a. Pull against anchored sections of CWR at least 400 feet long; and

    b. Stagger the anchored sections by at least five girder lengths to minimize the unbalanced loading of piers.

5. The temperature of aerial structures concrete shall be plus or minus 10 degrees Fahrenheit of the rails zero thermal stress temperature when the rail is anchored.

6. Maintain a uniformity of forces within the permitted tolerance in the CWR throughout the total length of the aerial structures.

L. Neutral Rail Temperature Verification:

1. The Contractor shall verify the neutral rail temperature by cutting the rail, releasing rail fasteners, vibrating, readjustment, and re-welding as provided herein.

2. Verification locations will be selected by the Engineer, one per mile on each track.

3. All neutral rail temperature verification shall be performed prior to Substantial Completion.

4. If the rail is found not to be within plus or minus 5 degrees Fahrenheit of that required, the Engineer shall select two additional locations for testing. For each additional location selected by the Engineer found not to be within plus or minus 5 Fahrenheit degrees of that required, two more additional locations may be selected for testing, and so on.

5. Testing shall be witnessed by the Engineer. The Contractor shall notify the Engineer of any tests and locations at least one week in advance. Simultaneous tests shall not be performed.

M. Fastener Protection:

1. Any damage to the rail fasteners caused by thermal rail adjustment operations shall be repaired or replaced.

2. Skewing, displacement or damages to ties, DF fasteners or resilient ties due thermal rail adjustment operations shall be repaired or replaced.

N. Calculate rail movement and gap between CWR strings by using the following equation:

$$G = [12LK(t-T)]+Q$$

Where	G	=	Rail gap (inches)
	t	=	Zero thermal stress temperature (degrees Fahrenheit)
	T	=	Actual rail temperature at time of laying (degrees Fahrenheit)
	L	=	Length of rail (feet); one-half the sum of lengths of CWR string being laid and the preceding CWR string.
	K	=	Coefficient of thermal expansion for rail steel (0.0000067 inches per foot per degree Fahrenheit)
	Q	=	Rail gap as required by respective manufacturers of field weld kit. For bolted standard joints, Q equals 0 inch, and for field installed insulated rail joints, Q equals the thickness of the end post, for in track electric-flash butt welds Q will be negative.

Note: if the above formula yields a negative value rail shall be added.

O. CWR Anchoring Plan: The Contractor shall develop and submit a detailed CWR Anchoring Plan that demonstrates the Contractor's procedure on how CWR strings, or any other disturbed rail, is to be welded together and anchored (fastened) within the specified neutral rail stress temperature range in accordance with the requirements herein. Layout sketches or drawings depicting the site-specific location of anchoring operations shall be included I the CWR Anchoring Plan.

P. CWR Anchoring Report: The Contractor shall maintain and submit records of all welding and anchoring operations, including completing the rail field weld record included as Figure 3 in Section 34 11 25, Running Rail, for each field weld.

3.06 TRACK TOLERANCES

A. Track construction tolerances for the various types of track are shown in Table 1, Track Geometry Tolerances and in Table 2, Other Track Construction Tolerances, and on the Contract Drawings. If any conflicts exist then the tolerances shown in Table 1 and Table 2 shall be used.

TABLE 1 - TRACK GEOMETRY TOLERANCES

	GAGE DEVIATION		**CROSSLEVEL / SUPER-ELEVATION DEVIATION**		**PROFILE DEVIATION**			**HORIZONTAL DEVIATION**		
TRACK TYPE	**UNIT[1]**	**TOTAL**	**UNIT[1]**	**TOTAL**	**UNIT[1]**	**Mid ordinate of 62' chord**	**TOTAL**	**UNIT[1]**	**Mid ordinate of 62' chord**	**TOTAL**
Ballasted, Main and Transfer	1/8" in 31'	±1/8"	1/8" in 31'	±1/8"	1/8" in 31'	±1/8"	±1/2"	1/8" in 31'	±1/8"	±1/2"
Ballasted Yard and Secondary	1/8" in 31'	±1/8"	1/8" in 31'	±1/8"	1/8" in 31'	±1/8"	±1/2"	1/8" in 31'	±1/8"	±1"
Resilient Ties and Direct Fixation Main and Transfer	1/8" in 31'	±1/8"	1/8" in 31'	±1/8"	1/8" in 31'	±1/8"	±1/4"	1/8" in 31'	±1/8"	±1/4"
Direct Fixation Yard and Secondary	1/8" in 31'	±1/8"	1/8" in 31'	±1/8"	1/8" in 31'	±1/8"	±1/2"	1/8" in 31'	±1/8"	±1/2"
All Special Trackwork	1/16" in 31'	±1/16"	1/8" in 31'	±1/8"	1/8" in 31'	±1/8"	±1/4"	1/8" in 31'	±1/8"	±1/4"

Notes:
1. Unit Deviation indicates a rate of change.
2. The ends of the chord must be at points on the gage side of the line rail, 5/8" below the top of the railhead.
3. Where conflicts in interpretation arise, the most restrictive deviation shall be used.

TABLE 2 - OTHER TRACK CONSTRUCTION TOLERANCES			
TYPE	**CRITERIA**	**TOLERANCE**	**NOTES**
Open Track	Track Gage	66”$\pm$1/8”	Distance between gage lines of opposite running rails.
All	Rail Cant	1 in 40 +1 degree, -0 degree	Except as noted on concrete tie and direct fixation special trackwork. Plus indicates inward cant.
Ballasted and Direct Fixation Track	Tie And Fastener Spacing	$\pm$1”	Of indicated spacing without accumulation
All	Station Platform Horizontal Alignment	30 5/8” -1/2”, +0”	Distance from Gage Line of the closest running rail to the Top of Platform Edge, measured in a plane parallel to that plane created by the tops of the two running rails
All	Station Platform Vertical Alignment	39” $\pm$1/2”	Distance from the plane created by the tops of the two running rails to Top of Platform edge
All	Third Rail Gage	26” $\pm$1/4”	Distance from Gage Line of the closest running rail to the centerline the third rail, measured in a plane parallel to that plane created by the tops of the two running rails
All	Third Rail Surface	6 3/4” $\pm$1/4”	Distance from tops of the running rails to the tops of the third rail, measured perpendicular to the plane created by the tops of the two running rails
All	Third Rail Joint Miss-Match	0” $\pm$1/32”	Measured using a 36” Straightedge
Ballasted	Overall Width	+2”, -0”	Measured from the centerline of track to edge of shoulder
Ballasted	Shoulder Width	12” +2”, -0”	Along both sides on tangents, the inside of all curves and the outside rail of Curves with radii greater than 2,000 feet.
Ballasted	Shoulder Width	18” +2”, -0”	Along the outside of curves with radii of less than or equal to 2,000 feet.
Ballasted	Shoulder Slope	2:1 +5°, -0°	
Ballasted	Depth Under Tie	12” +6”,-0”	

TABLE 2 - OTHER TRACK CONSTRUCTION TOLERANCES			
TYPE	**CRITERIA**	**TOLERANCE**	**NOTES**
Ballasted	Top Of Ballast Surface	1” +0, -1/2”	Depth below the plane formed by the bottom of the two running rails.
Special Trackwork	Track Gage	66” ±1/16”	Distance between gage lines of opposite running rails.
Special Trackwork	Tie And Fastener Spacing	±1/4”	Of indicated spacing without accumulation
Special Trackwork	Minimum Switch Rod Clearance (Horizontal)	1”	Minimum distance between switch rod (including bolts) and adjacent ties, plates and fasteners.
Special Trackwork	Minimum Switch Rod Clearance (Vertical)	1/4” ±1/8”	Distance between top of switch rod and bottom of stock rail.
Special Trackwork	Closure Curve Off-Sets And Spreads At Heels Of Frogs	±1/16”	As measured from the gage lines of the running rails. Unit deviation of no more than 1/8” in 31’
Special Trackwork	Guard Rail Location	±1”	In reference to the point of frog
Special Trackwork	Switch Point Stagger	±1/4”	
Special Trackwork	Point Of Switch Location	±1”	Of design Engineering station
Special Trackwork	Turnout Lead Length	±1”	Distance between point of Switch and ½” Point of Frog
Special Trackwork	Switch Point Throw At Each Switch Rod	±1/16”	Gap distance between gage line of stock rail and backside of switch point, measure with the point open.
Special Trackwork	Stock Rail to Stock Rail Gage	±1/16”	Distance between gage lines of adjacent stock rails.
Special Trackwork	Guard And Restraining Rail Check Gage	64 1/8” ±1/16”	Distance between guarding face of guard or restraining rail and gage line of opposite running rail.
Special Trackwork	Guard Rail Face Gage	62 1/4” ±1/16”	Distance between guarding faces through guard rails opposite frogs.
Special Trackwork	Guard Rail And Restraining Rail Flangeway Width	1 7/8” ±1/16”	

3.07 CONTRACTOR GEOMETRY INSPECTION

A. The Contractor shall employ a professional land surveyor or civil engineer currently licensed or registered in the State of California to make a survey of the track to determine if the horizontal and vertical alignment, gage, crosslevel, and superelevation are within the tolerances specified for each type of track construction.

B. Prior to Substantial Completion, the Contractor shall also make a complete inspection of the track using a rail mounted geometry inspection vehicle approved by the Engineer. Geometry measurements shall conform to the tolerances provided herein.

C. All deviations, which exceed tolerances, shall be repaired by the Contractor prior to Substantial Completion.

D. If deviations that exceed tolerances are found, additional repairs and geometry measurements shall be made until all tracks are within required tolerances.

E. The track geometry vehicle shall record the following measurements in a single pass.

1. Track gage.
2. Right rail surface (profile).
3. Left rail surface (profile).
4. Right rail alignment.
5. Left rail alignment.
6. Superelevation.

F. Measured Results:

1. All measurements shall be displayed on the same chart, in a linear format, for a length of track, 5000 feet to 6000 feet per page. Charts shall be calibrated and plotted in construction survey stationing.
2. Each measure shall be shown on a separate line with graduations at 0.25 in/div for all measurements except gage, which shall be shown at 0.12 in/div.

G. Ballast shall be inspected by the Contractor prior to the geometry inspections and re-inspections. Locations which show contaminants shall be re-tested as provided herein. If ballast fails any testing, the ballast shall be replaced.

H. Rust and mill scale shall be removed from the third rail and the running rail shall be ground prior to any track geometry measuring or testing. Refer to Article entitled “Third Rail Rust and Mill Scale Removal” herein for detailed requirements.

3.08 FINAL TRACK INSPECTIONS

A. The Contractor shall ensure that the track is free of all substandard conditions prior to Substantial Completion inspections. Substandard conditions found by the Engineer during Substantial Completion inspections, will delay Substantial Completion, until the track is again inspected by the Engineer and found free of substandard conditions.

B. The final horizontal and vertical alignment, gauge, crosslevel, superelevation, third rail surface, and third rail gage shall be within the tolerances specified. In order to determine the acceptability of the finished track, the Engineer will perform a final inspection to establish that the track construction is within the tolerances specified herein. The Contractor shall provide 30 days advance notice of the track's readiness for final inspection.

C. In addition to that required herein, tracks may be tested by the District's track geometry test car which is capable of testing gage, crosslevel, left and right rail profiles, track alignment, twist, warp, superelevation, left and right third rail gage and surface. The test car will measure the parameters specified above with sufficient accuracy to establish that the track construction is within the specified tolerances.

D. Unrestricted rail to rail access from the District's existing operating system to the track to be tested by the District's Track Geometry test car shall be provided by the Contractor, for the purpose of inspection and re-inspection.

E. Unobstructed and continuous access to the tracks to be tested shall be provided by the Contractor.

F. The Contractor shall correct track deviations that exceed specified tolerances as disclosed by the above specified inspections, and subsequent re-inspections.

G. The District will perform necessary re-inspections to ascertain that the corrections have been made. Re-inspections will include the use of the District's track geometry test car. The Contractor shall provide 30 days advance notice of the tracks readiness for re-inspection. Notification of re-inspection shall not be made until after all repairs have been completed.

H. The Contractor shall reimburse the District the full costs incurred by the District for re-inspections by the District's track geometry test car.

END OF SECTION 34 05 17

SECTION 34 05 42

COMMON MATERIALS AND METHODS FOR TRAIN CONTROL

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Resistors

B. Capacitors

C. Reactors

D. Electrical Connectors

E. Terminal Blocks

1.02 MEASUREMENT AND PAYMENT

A. General: Common materials and methods for train control, as specified herein, will not be measured separately but will be paid for as part of the Contract lump sum price for Automatic Train Control System Work as indicated in the Bid Schedule of the Bid Form.

1.03 REFERENCES

A. American Railway Engineering and Maintenance-of-Way Association (AREMA)

1. (Include applicable Part Numbers after they are verified)

B. American Society of Testing Materials (ASTM)

1. ASTM A-123

1.04 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Submit product information and catalog cuts of equipment and devices specified herein.

PART 2 – PRODUCTS

2.01 RESISTORS

A. All resistors, other than those required for electronic circuits shall meet the requirements of the AREMA Signal Manual, Part 14.2.15.

2.02 CAPACITORS

A. Capacitors provided for power factor improvement of ATC power distribution systems shall meet the requirements of the AREMA Signal Manual, Part 9.3.1.

B. All other capacitors provided, except those 10 mfd or less in electronic modules, shall have a maximum tolerance of plus 75 percent, minus 10 percent, and shall be rated for at least 1.5 times the maximum peak voltage to which they will be subjected in operation.

2.03 REACTORS

A. All reactors other than those in electronic circuits shall meet the requirements of the AREMA Signal Manual, Part 14.2.20.

2.04 ELECTRICAL CONNECTORS

A. A minimum of electrical connectors, and as few different sizes and types as practicable, shall be provided in all equipment. All connections shall be made using lugs or crimp or bolted connectors, as applicable. Connectors in vital circuits shall have a surface leakage distance of not less than 1/4 inch between metallic parts. The insulation shall withstand 3,000 VAC for one minute between metallic parts. Surface leakage distance from pin-to-pin and from pin-to-shell shall not be provided by selective use of pins. Connectors in non-vital circuits shall have a surface leakage distance not less than 0.1 inch between metallic parts. The insulation for connectors in non-vital circuits shall withstand 900 VAC for one minute between metallic parts.

2.05 TERMINAL BLOCKS

A. Terminal blocks shall be modular with solderless connections of the quick-connect tab, binding post and nut, screw terminal barrier, or wire wrap type. Terminal block insulating material shall conform to the requirements of the AREMA Signal Manual, Part 14.1.5;

B. Terminal blocks for vital circuits shall conform to the AREMA Signal Manual, Part 14.1.6. Ring tongue terminals shall be provided on all wires connected to the binding posts.

C. Solderless wire terminals shall conform to the AREMA Signal Manual, Part 14.1.1. Product information for terminals and crimping tools shall be submitted.

2.06 TRAIN CONTROL MISCELLANEOUS MATERIALS AND HARDWARE

A. Protective Hose Conduit: Protective hose conduit shall be braided synthetic material pneumatic type hose with a neoprene inner tube and cover. Hose shall be oil, water, abrasion, and ultraviolet resistant. Minimum inside diameter shall be 1/2 inch. Minimum outside diameter shall be one inch. Hose connectors shall be brass. Hose clamps shall be stainless steel.

B. Hardware: All hardware provided for outdoor installations shall be stainless steel unless indicated otherwise. Bolts, nuts, and threads shall conform to the AREMA Signal Manual, Part 14.6.20. Lock washers shall conform to AREMA Signal Manual, Part 14.6.21. Bolts, nuts, and washers for mounting and supporting equipment in indoor areas shall be cadmium plated, iridite dipped, or stainless steel. Brackets for mounting and supporting equipment and material in indoor areas shall be pre-galvanized then zinc chromate coated after fabrication. Brackets for outdoor installations shall be hot-dipped galvanized after fabrication in accordance with ASTM A-123. Damaged areas shall be repainted with zinc chromate after installation. Drive pins, lock washers, and hex nuts used with the B-188-3Q rail connections as indicated shall be made of carbon steel in lieu of stainless steel.

PART 3 – EXECUTION

Not Used

END OF SECTION 34 05 42

SECTION 34 11 23

SPECIAL TRACKWORK

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Special trackwork materials.

B. Fit of switch points.

C. Shop assembly.

D. Special trackwork assembly.

E. Switch machines.

F. Lubrication.

1.02 RELATED REQUIREMENTS

A. Refer to Section 34 05 17, Common Work Results for Trackway, for related requirements.

1.03 MEASUREMENT AND PAYMENT

A. General: Special trackwork will not be measured separately for payment. All costs in connection therewith will be considered as included in the applicable Contract lump sum price or the Contract unit price per linear foot for trackwork of the different types indicated as listed in the bid item in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. American Society of Mechanical Engineers (ASME):

1. ASME B18.8.1 Clevis Pins and Cotter Pins (Inch Series)

B. American Railway Engineering and Maintenance of Way Association (AREMA):

1. AREMA Manual.

C. American Society for Nondestructive Testing Inc. (ASNT):

1. ASNT-SNT-TC-1A Recommended Practice No. SNT-TC-1A, Personnel Qualification and Certification in Nondestructive Testing

2. ASNT-CP-105 Standard Topical Outlines for Qualification of Nondestructive Testing Personnel

D. American Society for Testing and Materials (ASTM):

1. ASTM A36/A36M Standard Specification for Carbon Structural Steel
2. ASTM A781/A781M Standard Specification for Castings, Steel and Alloy, Common Requirements, for General Industrial Use
3. ASTM E10 Standard Test Method for Brinell Hardness of Metallic Materials
4. ASTM E94 Standard Guide for Radiographic Examination
5. ASTM E709 Standard Guide for Magnetic Particle Testing
6. ASTM E164 Standard Practice for Contact Ultrasonic Testing of Weldments
7. ASTM E165/E165M Standard Practice for Liquid Penetrant Examination for General Industry

E. American Welding Society (AWS):

1. AWS B2.1/B2.1M Specification for Welding Procedure and Performance Qualification
2. AWS D1.1/D.1.1M Structural Welding Code - Steel

F. Society of Automotive Engineers (SAE):

1. SAE J534 Lubrication Fittings

1.05 SUBMITTALS

A. Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Submit the following for review and approval prior to special trackwork fabrication.

1. Shop drawings of each special trackwork unit, which detail each component and its proper position in the overall special trackwork layout. Drawings shall include all necessary dimensions, manufacturing tolerances and material descriptions for manufacturing the components as well as a table listing all components shown by name and by part number. Part numbers shall be assigned to components and to finished assemblies. All parts identified by the same part number shall have the same physical dimensions, material composition, performance characteristics and durability.
2. Field assembly plan for each special trackwork unit showing the turnout location, special trackwork identification code, unique color code and identification number of each component of the special trackwork unit. All components shall be match-marked for that particular special trackwork unit.

3. Methods used to relieve stress in the frog during fabrication.
4. Field assembly plans.
5. Welding, hardening and heat treating procedures.
6. Stress relief methods.
7. Test program plan.
8. Turnout work plans for each of the track forms used. Include comprehensive drainage plans and details.
9. Shop drawings of the derail and wheel crowder for each installation.
10. Restraining rail design.
11. Design of vertical safety guard rails.
12. General trackwork arrangement drawings for all special trackwork.
13. Certificate of compliance of tie pad (concrete ties).
14. Special trackwork materials product data, together with the manufacturer's recommended installation procedures for component parts, such as switch rods, rail braces, switch point rollers, auxiliary throwing device assemblies, and switch machines.

C. Submit the results of each production test specified herein for review and approval to the Engineer prior to shipping special trackwork.

D. Submit the method of packaging, loading, shipping, and handling the special trackwork and associated hardware for review and approval to the Engineer prior to shipment. For District-furnished materials, submit these in accordance with Section 01 64 13, District-Furnished Materials and Equipment.

E. Submit inventory records of special trackwork delivered at the time of each delivery. Identify identification and color code, as provided herein, for each unit. For District-furnished materials, submit these in accordance with Section 01 64 13, District-Furnished Materials and Equipment.

F. Submit test result reports.

G. Provide additional submittals as required herein.

1.06 QUALITY ASSURANCE AND CONTROL

A. A qualified independent testing laboratory approved by the Engineer shall perform all special trackwork inspection and testing. The selected laboratory shall employ the proper equipment and qualified testing personnel for the special trackwork testing and inspection described in these Specifications. Special trackwork testing and

inspection equipment and personnel shall be subject to approval by the Engineer. The Engineer will, or an independent witness designated by the Engineer shall, monitor the operations at the special trackwork plant to ensure that the inspections and tests are being performed in accordance with approved procedures and in compliance with these Specifications.

B. Personnel performing nondestructive testing shall be qualified and certified in accordance with ASNT SNT-TC-1A. Only persons certified for NDT Level I and working under a NDT Level II person or persons certified for NDT Level II may perform nondestructive testing.

C. Testing equipment shall be in good operating condition, of adequate capacity and range, and accurately calibrated. Testing equipment calibration shall be certified and traceable to national standards such as the National Institute of Standards and Technology. Testing equipment shall be calibrated in accordance with the requirements of the approved Construction Quality Plan specified in Section 01 45 00, Quality Control.

D. Test Program Plan

1. A test program plan shall be prepared identifying the approach for accomplishing each of the specified inspections and tests. A narrative shall be prepared for each required test and inspection specified, describing the test set-up; equipment, and instrumentation that will be used; procedure to be implemented; and the anticipated, as well as, acceptable test results. Drawings showing the relationship of the special trackwork and all significant components of the test equipment shall be included, as necessary, to describe the test set-up and procedure. The test program plan shall include the test sequencing.

2. Equipment specifications, and calibration methods for all testing equipment used to perform testing and inspection shall be included in the test program plan. The plan shall indicate the calibration certificates, which will be submitted with the test reports.

3. Identity and qualifications of personnel who will perform testing and inspection shall be included in the test program plan. Also include certification records for personnel who will perform nondestructive testing.

4. The test plan shall include the name and location of the testing facility, qualifications of the testing facility, a description of the testing facilities, and a layout of the test equipment that will permit the efficient performance of the testing.

5. The plan shall include the proposed format for reporting test data.

6. The projected schedule for test procedure submittals, test executions, and test results report submittals shall be included in the test program plan.

7. The test program plan shall address welding and bonded insulated joint testing separately. The test program plan shall also address qualification testing and production testing separately.

8. The test program plan shall include all geometry measurements of individual components and assemble units.

9. After approval of the test program plan, obtain the approval of any proposed changes from the Engineer, in writing, prior to implementing the change.

E. Test Reports

1. Test results shall be submitted, in bound units, for each special track work unit. The test results submittal shall not be submitted until complete.

2. No special trackwork shall be shipped until all components meet all of the quality requirements herein, and the Engineer has approved test results.

3. A report of test results of each test shall be submitted which includes test name, identification of test sample, test procedure references, test equipment identification, test personnel, time and date of test, specified requirements, actual test results, nonconforming items if any, and interpretation of the results. The format for the test report shall be arranged so that the data is presented in an orderly manner.

4. Standard, computer-generated test reports may be used upon approval of the Engineer. Such reports shall be supplemented, as required, to provide all information and test and inspection results required by these Specifications.

5. Copies of calibration certificates shall be submitted with the initial test reports. If test equipment is recalibrated while work is being performed, calibration certificates shall be submitted for the recalibrated test equipment with the test reports of the first tests performed after recalibration.

F. The Engineer shall be notified in writing not less than seven days in advance of dates scheduled for any tests, inspections, or shop assemblies. The Engineer retains the right to witness all tests.

G. The performance of the independent testing is entirely the responsibility of the Contractor. Any substandard conditions discovered after independent testing and inspection shall be repaired or replaced.

1.07 SPECIAL TRACKWORK IDENTIFICATION

A. All special trackwork components and units shall be uniformly identified in all submittals and documentation. Each special trackwork unit shall be assigned a unique identification number as shown in Table 1. In addition a unique color code for all various parts shall be used.

Table 1 - Special Trackwork Identification

Type	Identification Code
Turnouts	Interlocking and Switch Machine Number
Derails	Interlocking and Switch Machine Number

Table 1 - Special Trackwork Identification	
Type	**Identification Code**
Crossing Diamonds	Interlocking and the letter “D”. Where multiple crossing diamonds exist within an interlocking add sequential numbering for each unit.
Restraining Rails	By track and stationing range

1.08 SPECIAL TRACKWORK WORK PLAN

A. Prepare and submit a special trackwork plan with drawings for the Engineer’s approval prior to manufacture. Include the following information;

1. All design geometric measurements.
2. Accumulative tie and/or fastener spacing of switch ties, referenced from point of switch.
3. Closure curve offsets every ten feet from heel of switch.
4. Throw at each switch rod and at ten foot intervals beyond the last switch rod to the heel of switch.
5. Stock rail gauge line to gauge line distance at each switch rod and at ten foot intervals beyond the last switch rod to the heel of switch.
6. Gauge line spread, at intervals of one-half the frog number in feet, until the spread equals five feet.
7. Methods of installing switch points, stock rails, and switch rods to conform to tolerances and to provide the proper clearances between rods and switch ties and fit of switch points.
8. Include special trackwork identification codes and unique color codes to be used in turnout work plans.

B. Submit comprehensive drainage plan and details.

C. Install the initial turnout for inspection by the Engineer, using the approved work plan. If the initial turnout does not conform to the requirements specified herein, revise the plan in accordance with the inspection results of the initial turnout, replace or repair all non conforming items and resubmit to the Engineer for written approval prior to beginning work on subsequent turnouts.

D. General Trackwork Arrangement Drawings

1. All switch point assemblies shall be indicated on the general arrangement drawings, showing each component identification numbers, dimensional data for the assembly, and all control dimensions. All frogs and related special trackwork shall be indicated on the general arrangement drawings to show the relationship of all components related to the frog, such as guide rails including all control dimensions.

2. Vertical dimensions shall be referenced to bottom of rail. Horizontal dimensions shall be referenced to designated work points. Each part shall be tagged or marked according to the assigned special trackwork identification code and shall receive a unique color code for easy identification and field sorting of components.

1.09 RESILIENT TIE AND DIRECT FIXATION SPECIAL TRACKWORK CONSTRUCTION METHOD QUALIFICATION

A. In addition to the other requirements herein, the Contractor shall prepare and submit to the Engineer a separate construction work plan for resilient tie and direct fixation special trackwork under the requirements specified in Section 34 11 24, Direct Fixation Track. The work plan for special trackwork shall be separate from that for standard DF or resilient tie track.

1.10 WELDING

A. Welders and welding operators shall be qualified in accordance with AWS D1.1/D1.1M, AWS B2.1/B2.1M, or other standard approved by the Engineer.

B. Miscellaneous rolled, forged, or cast steel accessory components may be welded provided the carbon content does not exceed 0.40 percent and provided a 200 degree Fahrenheit minimum preheat is used for any material with a carbon content greater than 0.30 percent. Welding procedure specifications shall be qualified in accordance with AWS B2.1/B2.1M, AWS D1.1/D1.1M, or other standard acceptable to the Engineer.

C. Welding of rail steel is not acceptable.

D. Welding of cast iron is not acceptable.

E. Welding of Manganese

1. No welding repairs shall be made without the Engineer’s written approval, in advance of repairs; such approvals will be made on a case by case basis.

2. Welding repairs shall not be performed within the wheel contact area.

3. Welding repairs shall only be performed at the manufactures facility.

4. Welding repairs shall be made with the unit removed from the track and in a shop environment.

5. Manganese welding repair procedure specifications shall be qualified by combinations of mechanical tests, hardness tests, nondestructive examinations, and metallographic examinations which demonstrate, to the Engineer's satisfaction, that the repair weld metal and heat affected zone meet the requirements of the of manganese base metal.

6. The requirements for each repair weld qualification shall be made on a case by case basis, by the Engineer.

7. Manganese repaired without advance approval of the Engineer shall be rejected.

1.11 PACKAGING, LOADING, SHIPPING, AND HANDLING

A. Handle special trackwork materials in a manner that will prevent damage during packaging, loading, and transporting. Exercise care in unloading and handling materials to prevent breaking or bending or in any way damaging the material. Materials shall be neither dropped nor thrown from cars, but shall be lifted or skidded to the ground or other surface. Do not sharply strike special trackwork.

B. Packaging and Identifying

1. Band all switch rails and stock rails together in one package for each turnout unit. Identify switch rails to indicate the turnout number. Identify stock rails to indicate the turnout number and whether right-hand or left-hand.

2. Package all frogs as a single unit per turnout, and identify to indicate the turnout number.

3. Band guard rails together; separately, and identify as to which turnout it is to accompany.

4. Package switch plates, frog plates, guard rail plates, standard plates, gauge plates, and other small loose parts in separate units. Package the units in secure shipping boxes or kegs. Package the required number of units with each turnout, and identify as to which turnout it is to accompany. Band all switch rods within a turnout unit together in a single package, and identify as to which turnout it is to accompany.

5. Package all rail crossing frogs as individual units, and identify to indicate both the special trackwork item and its position within the item.

6. Package rail crossing frog plates in separate units, and identify to which crossing it is to accompany.

7. Band rail crossing guard rails together; separately, and identify to indicate the rail crossing intended.

8. Units, bundles, and boxes shall be clearly marked with the following information: identification of item contained, manufacturer's name, shipping date, unit designation (right or left), number of pieces, destination, and gross weight.

9. Special trackwork shipments shall be adequately prepared and protected to preclude damage during shipment.

10. Bolts shall be delivered with a wax or petroleum based coating, or similar water resistant coating, as thread protection against rusting before installation. The remainder of the bolt surface shall have a light coating of oil.

11. Standard bonded insulated joints for shall be bundled by turnout identification number.

12. Package standard and special rail clips separately.

PART 2 – PRODUCTS

2.01 DISTRICT-FURNISHED MATERIALS

A. Refer to Section 01 64 13, District-Furnished Materials and Equipment, of the Contract Specifications for description and quantity of District-furnished materials.

2.02 CONTRACTOR-FURNISHED MATERIALS

A. All products, tools, materials, equipment and labor required to complete all aspects of the work shall be furnished by the Contractor, and the following.

B. Provide explosion hardened frogs, without depressed point or ring wheel risers.

C. Provide switch geometry as indicated on the Contract Drawings.

D. Provide switch points and stock rails as indicated in the Contract Drawings.

E. Switch point rollers shall be the design recommended by the manufacturer of the special trackwork. Roller installation shall not require modification of the switch point drilling shown in the Contract Drawings.

F. Heel block assemblies shall be as indicated on the Contract Drawings. Heel blocks shall be carbon steel castings conforming to AREMA Specifications Article M3.

G. Switch rod assemblies shall be insulated, vertical design, the Designated Matching Products specified in the Contract Drawings.

H. Grease fittings shall conform to SAE J534. Grease fittings shall be non-corrosive material, capable of withstanding 10,000 psi maximum pressure.

I. Adjustable Rail Braces

1. Adjustable rail braces shall be the Designated Matching Product specified in the Contract Drawings.

2. Castings shall conform to AREMA Specifications, Article M3.

3. Rail brace assemblies shall comply with the fit requirements for Type A or B braces shown on the AREMA Portfolio, Plan No. 224.

4. Incorporate adjustable rail braces specified herein.

J. Frog, Switch, and Guard Rail Tie Plates

1. Plates shall conform to the AREMA Specifications, Article M7, and ASTM A36/A36M. Plates for concrete turnout ties shall conform to the AREMA Specifications, Article M7, and ASTM A36/A36M.

2. Plates shall be straightened cold in a press or roller machine to remove twists, waves, and kinks until they meet the required surface and line requirements. Holes in plates shall be punched or drilled through each plate perpendicular to its face, and shall be clean cut, leaving no torn or ragged edges. Drilled bolt holes shall be peened or ground to remove sharp edges.

3. Welds on special plates shall be fillet welds conforming to AWS D1.1/D1.1M.

4. Hook twin plates are not allowed.

K. Bolts, nuts, and spring washers shall conform to AREMA Specifications, Articles M11 and M12.

L. Rivets shall conform to the AREMA Specifications, Article M13.

M. Cotter pins shall be extended prong type conforming to ASME B18.8.1.

N. Castle nuts shall be full bearing, conforming to the AREMA Specifications, Article M11.

O. Switch machines, switch operating rod, lock rod, detector rods, lugs, baskets, and associated hardware are specified in the Contract Specifications. Mounting of switch machines shall be interchangeable with the District’s existing machines.

P. The bolts used with castle nuts shall have the holes drilled for the cotter pins to provide a proper fit of the cotter pin and engagement of the castle nut.

Q. Switch points, stock rail and frogs shall have an aluminum tag permanently attached to the gauge side of the rail. Tags shall identify switch length, frog number, rail section, curved or straight, right-hand or left-hand, manufacturer, fabrication date and, weight as applicable and shall clearly marked at the center of gravity for lifting.

1. Incorrect markings shall be removed.

2. Tags if found to be incorrectly marked cannot be altered, but shall be replaced.

R. Turnout Plate Anchorage Assemblies

1. All ties of the same length shall be identical except for the addition of conduits and as follows:

   a. Ties supporting switch machines for all turnout types and derail layouts may be different than ties of the same length used at other locations; however, these ties shall all be identical and work for all switch types, layouts and types of switch machines.

   b. Ties supporting auxiliary throwing device may differ from other ties of the same length only by the addition of the anchorage assemblies required for the auxiliary throwing device.

2. A single insulating pad shall be provided under each special plate. Pads shall be the same type and thickness and shall extend at least 1/2-inch beyond the sides and the end of the plate.

3. The design of special plates on concrete special trackwork ties shall also include the following:

   a. Turnout plates shall be secured to the tie with a minimum of one embedded shoulder assembly, one on each end of the plate.

   b. Each embedded shoulder assembly shall include a shoulder, an insulator and clip of the same type used for concrete ties.

S. Stamped markings shall be to a nominal depth of 1/16 inch; deep stamping shall be avoided. Plate and switch rod assembly identification markings shall be clearly stamped with letters and figures not less than 1/2 inch in height, located on the top surface of the plates, plainly visible when assembled, and not subject to wear. Markings shall include rail section, left hand, right hand or equilateral, switch length, and plate number.

T. Source Quality Control

1. Production quality control testing and inspection shall be in accordance with that provided herein.

2. Production Testing

   a. During special trackwork fabrication, perform the tests and inspections specified in the AREMA Specifications and herein to ensure compliance with these Specifications.

b. Perform all tests and inspections in accordance with the AREMA Specifications and as specified herein. Tests shall be performed in accordance with the approved Test Program Plan and test procedures.

3. Magnetic Particle Inspection

a. Examine each forging and weld by the dry powder method of magnetic particle inspection in accordance with ASTM E709. All forging surfaces shall be examined. Acceptance examination shall be performed at ambient shop temperature. Examination shall be performed prior to any hard surfacing.

b. Forgings shall be free of relevant linear indications. The forgings shall be free of defects or other injurious imperfections.

c. Forgings and welds may be examined by the liquid penetrant method in accordance with ASTM E165/E165M in lieu of the magnetic particle examination.

4. Ultrasonic Tests

a. Perform ultrasonic testing on all forgings and welds in accordance with ASTM E164 and the additional requirements listed below.

b. An ultrasonic testing procedure that is in accordance with these Specifications shall be developed. The transducer angles and scanning directions shall be fully described.

c. The procedure specifications shall provide for complete volumetric coverage of all forgings.

d. The procedure specifications shall provide for complete volumetric coverage of all welds and adjacent weld heat affected zones (HAZ). The head surface and both sides; weld and HAZ in base flanges shall be examined from at least the bottom flange surface and both web surfaces. Flash butt welds shall also have the web examined. At least three transducer angles shall be used from each surface unless otherwise approved by the Engineer.

e. The ultrasonic test equipment shall be capable of detecting a 3/64-inch discontinuity within the forging or weld. The sensitivity and resolution of the proposed equipment shall be demonstrated using appropriate area amplitude and distance amplitude reference blocks made of material similar to the steels being tested. All equipment shall be equipped with a distance amplitude correction feature. The equipment will be calibrated daily using an International Institute of Welding calibration block, also made of steel.

f. The examination shall be performed prior to any hard surfacing.

g. Forgings and welds will be rejected if any discontinuations of 3/64 inch or greater are discovered.

5. Liquid Penetrant Examination

a. Liquid Penetrant Examination Requirements

1) Liquid penetrant examination shall be performed in accordance with ASTM E165/E165M.

2) The examination shall be performed prior to any hard surfacing.

3) Hard surfacing and adjacent heat affected zones shall be examined. Cavities in castings that are to be repaired shall be examined. Completed weld repairs shall also be examined.

4) Finished manganese steel castings shall be examined after sheet explosive depth hardening.

b. Liquid Penetrant Examination Acceptance Criteria

1) Cracks, seams and voids are not acceptable.

2) All hardsurfacing and heat affected zones shall be free of defects or other injurious imperfections.

3) Manganese steel castings with cracks or linear indications, sand pockets, porosity, or slag shall be rejected. Other conditions shall comply with AREMA requirements.

c. Forgings and welds may be examined by the magnetic particle examination method in accordance with ASTM E709 in lieu of the liquid penetrant examination.

6. Hardness Tests

a. All frog points shall be Brinell hardness tested on the head and along the side wearing surfaces in accordance with ASTM E10. Frogs shall be tested at mid-length and at the point.

b. The hardness test results shall be 352 BHN minimum on bearing or wearing surfaces, and 321 BHN minimum elsewhere. The hardness test results on manganese steel castings shall comply with AREMA Specifications, Article M2.

7. Radiographic Examination

a. All castings of manganese steel for frogs or crossings shall be radiographed in accordance with ASTM A781/A781M supplementary requirement S2 (ASTM E94). The film quality shall show two percent sensitivity (2-2T). Radiography shall be performed before explosive hardening.

b. Castings with cracks, tears, or shrinkage shall be rejected. Casting shall be free of sand holes, sand inclusions, gas pockets or porosity, cold shuts, and inserts which would impair serviceability.

c. All miscellaneous welds, such as those used to fabricate plates, shall be visually inspected. All miscellaneous welds shall meet the acceptance criteria of AWS D1.1/D1.1M.

U. Furnish auxiliary throwing devices to provide a positive throw throughout the full length of the switch, on turnouts with switch points longer than 26 feet 6 inches. The auxiliary throwing device shall have successful revenue service experience under conditions equivalent to those found in the BART System. Auxiliary throwing devices shall connect to the #2, #5 and #7 switch rods, be the same type for all switches provided and shall be interchangeable.

V. Hayes Model HBP, size eight, sliding derail and wheel Crowder is a “Designated Matching Product”. The layout of the equipment with rods for power operation by a switch machine shall be as indicated in the Contract Drawings. The BART standard switch machine is the Alstom GM4000A.

W. Provide vertical safety guard rails adjacent to aerial special trackwork at locations and as indicated in the Contract Drawings.

PART 3 – EXECUTION

3.01 FIT OF SWITCH POINTS

A. Switch point shall fit tight against the stock rail for 85 percent of the switch point side planing. Maximum clearance at end of side planing: 1/16 inch. When closed the switch point shall be parallel with the stock rail, the first 12 inches shall fit tightly. As the point closes, the point shall come into uniform contact with the stock rail and the point end shall contact the stock rail first.

3.02 SHOP ASSEMBLY

A. Shop-assemble all turnouts, track crossings and derails in accordance with the approved Shop Drawings.

1. All special trackwork units shall be completely assembled and inspected at manufacturers production facility prior to shipment.

2. Where different special trackwork units share the same ties, connected ties or fasteners, they shall be assembled as a single unit.

3. Shop assemblies shall be complete and shall include all rails, ties, fasteners, resilient ties, direct fixation fasteners, switch machines, auxiliary throwing devices and train control rods.

4. All rail and materials used in the shop assembly shall be the same as that used for field installation for that particular special trackwork unit.

5. All nuts, bolts and other fasteners shall be installed, completely assembles and properly tightened.

6. All parts used for the shop assembly shall have the unique identification number and unique color code applied as required herein, applied prior to any inspections.

7. Test, inspect and operate the equipment prior to disassembly and shipment.

8. Repair any defective conditions found, reassemble, retest, reinspect, and operate the equipment until all requirements are met.

9. Shop assemblies shall be performed on a reasonably smooth surface to ensure adequate inspection for conformance to all requirements herein.

10. Shop assembly shall not include rail welding. Rail shall be adequately joined with temporary joints to ensure compliance with the quality requirements herein.

11. All required traction power ground return bonding cables and train control bonds shall be installed.

B. Shop assembled special trackwork shall be inspected, where applicable, for adherence to the following criteria:

1. Fit and Functionality;

2. Alignment;

3. Gage;

4. Track Centers;

5. Distances between frogs on crossovers;

6. Heel drilling and spread;

7. Location and drilling of holes;

8. Length of side cut;

9. Fit of stock rails to switch points;

10. Fit of rails, switch points and frogs in plates and/or rail seats;

11. Thickness at point;

12. Fitness of rails, switch points, stockrails, frogs and other manufactured parts;

13. Location of switch point stops;

14. Length;

15. Switch rod clearance;

16. Lead;

17. Spreads and off-sets;

18. Frog/Guardrail Guard Face Gage;

19. Frog/Guardrail Guard Check Gage; and

20. Additional measurements required to ensure that the final installation will meet all applicable requirements.

C. Except as required for resilient ties and direct fixation fasteners, no bracing will be permitted to hold components to proper gage.

D. Contractor shall provide (or obtain through the trackwork manufacturer) templates, cranes, and other reasonable facilities and assistance required for inspection by the Engineer.

3.03 SPECIAL TRACKWORK ASSEMBLY

A. Construct special trackwork within the specified track and turnout tolerances herein.

3.04 SWITCH MACHINES

A. Installation shall conform to the manufacturer's installation procedures and recommendations supplemented by the Contractor's work plan specified herein.

B. Installation shall not begin until the track is at profile grade and final surfacing, alignment, ballast compaction, and regulation are completed.

3.05 LUBRICATION

A. Clean all slide plates and the tops of switch rods where they are under the stock rails and apply a uniformly thick coat of wet applied dry graphite lubricant over the entire sliding surface in accordance with the manufacturer's recommendations.

B. No grease may be used on slide plates, sliding surfaces or switch rods, the tops of switch rods or underside of stock rails. If grease is found on the slide plates or switch rods, all affected surfaces shall be immediately steam cleaned and graphite lubricant reapplied.

C. All grease fittings on switch mechanisms shall be lubricated using a product recommended by the manufacturer. Excess grease shall be removed.

D. The responsibility for the operation and maintenance of the switch machine, switch adjustment, connecting rods and switch lubrication through the construction and testing phase remains with the Contractor.

3.06 RUNNING RAIL-TO-GROUND RESISTANCE TESTING

A. As part of the reduction or mitigation of stray current resulting from normal operations, the Contractor shall include in the development of the final ballasted special trackwork installation specifications, provisions for conducting tests for running rail-to-ground resistance:

1. After essential completion of the installation for any given special trackwork section.

3.07 RUNNING RAIL RESISTANCE TESTING

A. As the running rails are an essential part of the negative return system, the Contractor shall include in the development of the final ballasted special trackwork installation specification, provisions for conducting tests of running rail resistance:

1. After essential completion of the installation for any given special trackwork section.

2. The tests shall be conducted to confirm that the resistance of the four running rails in parallel shall be no greater than 0.002175 ohms per 1,000 feet at 30 degrees Celsius.

B. Contractor shall also provide a detailed narrative of the testing methods and procedures to be used in confirming the running rail-to-ground resistance to the Engineer for approval prior to conducting field testing. The detailed narrative shall at a minimum contain provisions for:

1. Quality control of the testing, including:

   a. Testing by an independent company to be proposed by Contractor.

   b. Number of readings to determine electrical constant (used in calculations), and

   c. Final acceptance of test based on quality assurance verification test.

2. Submittals, including:

   a. Testing Group: names of agency employed for this testing.

   b. Testing Technique: detailed written description of testing proposed,

   c. Instrumentation: listing of instruments and their particulars including model numbers and make as appropriate,

   d. Documentation: test data sheets showing format for record,

   e. Test Results: data and calculations including summary tabulations of results for each test track sections for review and approval, and

   f. Schedule: a three-month look-ahead schedule for all planned tests.

3. Execution, including:

   a. Scheduling of tests in accordance with approved look-ahead schedule,

   b. Visual inspection of the track section ready for testing, and

   c. Electrical testing of mainline trackwork and special trackwork sections and specifying in detail the method used:

1) Where the running rail insulating joints have been installed,

2) Where the track section adjacent to the particular section under test has not yet been installed.

3) For each method above, the applicable calculation equations to accomplish the required test shall be presented.

d. Definitions of acceptance criteria:

1) Minimum acceptable values for the particular track type.

2) Procedure to be followed when the section of the track fails the test.

C. In lieu of the detailed narrative described above, Contractor may propose to the Engineer for approval, a separate specification section to accomplish the required testing.

END OF SECTION 34 11 23

SECTION 34 11 24

DIRECT FIXATION TRACK

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Direction fixation track materials.

B. Concrete surface preparation.

C. Protection.

D. Forms.

E. Pre-pour survey.

F. Concrete finishing.

G. Track installation.

1.02 RELATED REQUIREMENTS

A. Refer to Section 34 05 17, Common Work Results for Trackway, for related requirements.

B. Refer to Section 34 11 93, Track Appurtenances and Accessories, for procurement and related requirements for rail fastener materials.

C. Refer to Section 34 11 32, Resilient Ties, for procurement and related requirements for RT materials.

D. Refer to Section 34 11 37, Direct Fixation Fasteners, for procurement and related requirements for DF materials.

1.03 MEASUREMENT AND PAYMENT

A. General: DF track, DF Special trackwork and RT track will not be measured separately for payment. All costs in connection therewith will be considered as included in the applicable Contract lump sum price or the Contract unit price per linear foot for trackwork of the different types indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):

1. AASHTO T277 Standard Method of Test for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration

1.05 SUBMITTALS

A. Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Work Plans: Submit construction work plans for RT, DF track, and DF special trackwork. Plans shall be prepared and sealed by a civil engineer currently registered in the State of California.

C. Product Data: Submit product data for non-shrink grout and metal preservative.

1.06 RESILIENT TIE, DIRECT FIXATION TRACK, AND DIRECT FIXATION SPECIAL TRACKWORK CONSTRUCTION METHOD QUALIFICATION

A. In addition to the other requirements herein, the Contractor shall prepare and submit to the Engineer separate construction work plans for RT, DF track, and DF special trackwork in accordance with the track requirements and tolerances specified herein. If the work plan is acceptable, the Engineer will issue permission to proceed with a demonstration section.

B. Each work plan shall, at a minimum, include the following applicable items:

1. Step by step construction sequence.
2. Survey control plan.
3. Material handling procedure.
4. Special equipment and tools.
5. Shop Drawings of forms, jigs and supports.
6. Method of protecting supports to allow removal after concrete installation.
7. Method of treating holes in the concrete created by temporary supports.
8. Concrete surface and dowel preparation.
9. Proposed methods of repairing damaged concrete base caused by over water jetting.
10. Methods of protecting existing drainage from deleterious material during construction.
11. Methods of collected and removing washed material, debris and dust.
12. Forming, placing, finishing, and curing of track concrete.
13. Repair procedures non-conforming concrete.
14. Method of measuring and repairing any voids in the bearing area.

15. Replacement procedures for damaged or incorrectly installed anchor bolt and third rail inserts, including torque and pull out testing that ensures compliance with the requirements.

16. Installation of DF rail fastener, including the anchor bolt installation torque and the sequence of shimming, torquing anchor bolts, and applying rail clips.

17. Installation of RT assemblies and the sequence of applying rail clips.

18. Coordination between the installation of various track types, including standard and special trackwork.

19. Installation of DF rail fastener or RT assemblies, including where applicable the anchor bolt installation torque and the sequence of shimming, torquing anchor bolts, and applying rail clips; all in accordance with the manufacturer's instructions.

20. Repair procedures for deviations in track gage, surface, rail cant, alignment, skewed RT and DF fastener assemblies and for non-conforming insert locations.

21. Methods of installing switch normal to the tangent line and within location tolerances.

22. Methods of installing switch points, stock rails, and switch rods to conform to required tolerances and to provide the proper clearances between rods and track concrete.

23. Coordination of the plan for installing the switch machine and all rods with trackwork.

24. Equipment and method to be used to install the RT and DF fastener assemblies to correct surface, alignment and gage and crosslevel.

25. Shop drawings of purpose manufactured gage supports to support track, fasteners and/or inserts prior to and during concrete placement.

26. Method and equipment for holding stock rails, switch rails, or frog wing rails when welding to adjacent rails.

27. Method for purging water from rubber boots and sealing drainage holes on RT fasteners.

28. Methods for rail anchoring and rail welding.

29. CWR handling and installation.

30. CWR adjusting, rail welding, and anchoring to conform to the neutral rail temperature requirements and to protect the aerial structure girders and piers.

31. Field testing and inspection to conform to the quality requirements and tolerances specified herein.

32. A comprehensive drainage plan.

33. Each construction work plan shall include written approval of the plan by the manufacturers of the RT and DF fasteners, as applicable.

C. Demonstration Section:

1. Upon receiving the Engineer's permission to proceed, the Contractor shall verify its work plan by constructing a demonstration section of track, for approval by the Engineer before beginning construction of trackwork on a production basis.

2. The exact methods the Contractor proposes to use shall be employed for the demonstration section.

3. Separate demonstration sections shall be installed for each type of track construction used.

4. Separate demonstration sections shall be provided for each type of special trackwork construction.

5. Demonstration sections for standard track shall be between 100 and 1000 feet long and for special trackwork, at least one complete turnout.

6. The manufacturers' representatives of the RT and DF fasteners, as applicable, shall be present throughout the construction of and any repairs made to the demonstration section. Each representative shall submit its approval of the demonstration section, in writing, to the Engineer. Any recommendation for changes to the work plan, by the manufacturer's representative, shall be integrated into the revised work plan.

7. If the demonstration does not meet the indicated requirements, the Contractor shall submit a revised work plan and construct another demonstration section or sections.

8. Non-conforming demonstration sections shall be removed or repaired by methods approved by the Engineer.

9. Location of the demonstration section(s) shall be as indicated on the Contract Drawings.

10. The Engineer will approve or disapprove each demonstration section within two weeks of completion.

11. The demonstration section shall include examples of the various forms of repair described in the work plan.

D. Production Work:

1. The Contractor shall use only approved methods and procedures as shown and demonstrated for production work.

2. No construction may begin for a particular track type until the Engineer approves the demonstration section for that particular type of track construction.

PART 2 – PRODUCTS

2.01 DISTRICT-FURNISHED MATERIALS

A. Refer to Section 01 64 13, District-Furnished Materials and Equipment, of the Contract Specifications for description and quantity of District-furnished materials.

2.02 CONTRACTOR-FURNISHED MATERIALS

A. All products, tools, materials, equipment and labor required to complete all aspects of the work shall be furnished by the Contractor, and the following.

B. Reinforced Track Concrete:

1. Except for the modifications indicated herein and on the Contract Drawings, all work shall be in accordance with the following Sections: 03 15 00, Concrete Accessories, 03 20 00, Concrete Reinforcing, 03 30 00, Cast-in-place Concrete, and 03 05 15, Portland Cement Concrete.

2. Provide portland cement concrete for track concrete conforming to the following requirements:

3. Provide Class 4000-3/4 inch concrete, unless otherwise indicated.

4. Cement content shall be a minimum of six-and-a-half 94-pound sacks of portland cement per cubic yard.

5. Coarse aggregate shall be washed clean and graded within the limits shown in Table 1.

6. Grading limits for combined coarse and fine aggregates shall be within the limits shown in Table 2.

Table 1 - Coarse Aggregate Cleaning and Grading Limits

Sieve Size	Percentage Passing Sieve
3/4 inch	100
1/2 inch	90-100
3/8 inch	0-100
No. 4	0-15
No. 8	0-5

Table 2 - Combined Coarse and Fine Aggregates Grading Limits	
Sieve Size	**Percentage Passing Sieve**
3/4 inch	100
1/2 inch	95-100
3/8 inch	45-100
No. 4	35-60
No. 8	30-45
No. 16	20-35
No. 30	10-25
No. 50	5-15
No. 100	2-5

7. Slump: The average slump shall not exceed three inches.

8. Unit water content shall not exceed 325 pounds of free water per cubic yard.

9. Conform to the aggregate reactivity requirements of Section 03 05 15, Portland Cement Concrete, Paragraph 2.01.C, Special Aggregates for Reducing Shrinkage and Creep.

10. All reinforcing steel shall be epoxy coated as specified in Section 03 20 00, Concrete Reinforcing.

11. All openings through the track concrete for electrical wires or drainage shall be formed from PVC electrical conduits in accordance with applicable requirements of Section 20 50 13, Raceways for Facility Services.

12. Additional Requirements for Direct Fixation Track:

    a. For the purpose of increasing the electrical resistivity of the concrete in order to reduce the effect of stray currents, the concrete mix design shall incorporate the use of silica fume. The dosage rate shall be a minimum of five percent by weight of the portland cement used in the mix. The water cement ratio shall be calculated on the basis of the combined weight of portland cement and silica fume.

    b. Test proposed concrete mix in accordance with AASHTO T-277, and submit test report. Rating of very low shall be achieved at 56 days by discreet testing and not by interpolation of test data. Such evidence shall consist of data from the following tests: two sets of specimens shall be prepared and tested using the AASHTO T-277 procedure. The first set of specimens shall be moist cured for a period of 28 days, then placed in an air drying facility maintained

at 73 degrees Fahrenheit, plus or minus three degrees, and 50 percent relative humidity, plus or minus five percent, until an age of 56 days, then tested. The second set of specimens shall be cured in a manner identical to that applied to the actual track concrete (damp cure for seven days), then placed in the air-drying environment noted above until an age of 56 days. A two-inch thick slice shall be obtained from the central portion of each cylinder and used for the test specimen. No fewer than three test specimens shall be prepared and tested for each mix to be evaluated.

PART 3 – EXECUTION

3.01 GENERAL

A. Construct RT, DF track, and DF special trackwork in accordance with applicable requirements and as indicated on the Contract Drawings.

B. Resilient Tie (RT) trackwork construction includes independent concrete block ties with rubber boots, resilient block pads, rail fasteners and lateral adjustment shims.

C. Direct Fixation (DF) trackwork and Direct Fixation Special Trackwork construction, consisting of DF fastener assemblies, rail fasteners, shims and anchor bolt assemblies.

D. Both types of track construction include the requirements for qualifying the construction methods; surface preparation of existing concrete; placing fastener assemblies; forming, placing, and curing track concrete; and installing continuous welded rail (CWR); and, provision for mounting the third rail and third rail assemblies and track concrete.

3.02 EXAMINATION

A. The concrete substrate on which the track concrete is placed shall only vary from the design elevation within the range shown in Table 3. Correct out-of-tolerance substrate using means acceptable to Engineer.

Table 3 – Allowable Variance Prior To Placing Track Concrete

Type of Construction	Allowable Variance
Subway, U-Wall invert or At-grade slab	Plus 1 inch to minus 2 inches
Aerial structure decks on spans up to and including 100 feet	Plus 1 inch to minus 3 inches
Aerial structure decks on spans exceeding 100 feet	Plus 1 inch to minus 5 inches

3.03 CONCRETE SURFACE PREPARATION

A. Prepare and clean the concrete substrate to receive the track concrete as a construction joint, using high-pressure water blast methods.

B. Preparation, cleaning, and high-pressure water blasting shall be performed prior to placing rail, RT or DF assemblies and formwork.

C. High-pressure water blasting shall expose a minimum 1/8” of the aggregate, without causing damage to the aggregate. The Contractor shall determine the water pressure and nozzle type. The Contractor shall demonstrate that the proposed pressure is adequate to expose the required amount of aggregate.

D. The water jetting shall be restricted solely to the area directly under the track concrete. Any over jetting shall be repaired as approved by the Engineer.

E. Immediately prior to concreting, the supporting structure concrete shall be thoroughly cleaned with clean water and compressed air to remove all loose material and dirt.

F. Deleterious material shall not be flushed down the drainage.

G. Washed material and resulting debris and dust shall be collected and removed by means proposed by the Contractor and approved by the Engineer.

3.04 PROTECTION

A. Protect dowels, drainage facilities, and electrical conduits from damage and plugging. Repair promptly all damage due to Contractor’s operations.

3.05 FORMS

A. Design and install forms in accordance with Section 03 11 00, Concrete Forming.

3.06 PRE-POUR SURVEY

A. Immediately prior to pouring track concrete, the formwork and supporting jigs shall be surveyed for readiness.

B. The survey shall take place no more than four hours prior to placing track concrete.

C. The survey shall be performed by, or under the direction of, a professional land surveyor or civil engineer currently licensed or registered in the State of California.

D. Measurements shall be taken at each support location and shall include, at a minimum, alignment, surface and elevation and cant of both rails, gage and crosslevel.

E. No track concrete may be placed prior to repairing any deviations found during the inspection.

F. All measurements shall be recorded and submitted to the Engineer on the same day that the measurements are made.

3.07 CONCRETE FINISHING

A. Finish the track concrete in accordance with the requirements of Section 03 35 00, Concrete Finishing, and the following requirements:

1. Finish shall conform to “smooth form finish” on the sides and “floated finish” on the top surface.

2. Cure track concrete with waterproof sheet material or damp burlap.

3. Concrete shall be free of cracks, with particular emphasis in the vicinity of inserts; all cracks shall be repaired using the approved method.

4. Concrete voids due to trapped water or air in the rail fastener bearing seat shall not exceed the following limits:

    a. Single void: 1/2 inch diameter.

    b. Total voids: Ten percent of the total area.

5. No traffic whatsoever shall be permitted to run over the track nor shall manufactured gage supports be removed, for any reason, until the concrete has achieved a minimum compressive strength of 2000 psi. The Contractor shall demonstrate, to the satisfaction of the Engineer, when the concrete has reached the minimum compressive strength to allow the gage supports to be removed or traffic to run over the track.

B. Direct Fixation Track and DF Special Trackwork:

1. The fastener assembly, including shim shall not be recessed into the concrete.

2. Remove forms and expose the entire rail fastener bearing seats for each construction cycle for the Engineer’s inspection.

3. Finish all rail seat areas in accordance with a plan approved by the Engineer.

4. The concrete surface under the DF rail fastener shall be installed to a plane that provides uniform bearing under the fastener.

5. Difference in height from top of rail to top of track concrete between adjacent rail fasteners shall not exceed 1/16 inch.

6. The top of the track concrete shall be free of depressions that will cause water to pond.

7. The concrete between adjacent rail fasteners shall be uniform and not vary more 1/16 inch as measured with a 12 inch straight edge.

C. Resilient Tie Track:

1. The rails and RT assemblies shall be lifted in the presence of the Engineer at a maximum of 1000 foot intervals to check for air pocket occurrence.

2. Where the voids exceed 10 percent across the full bearing area, further track shall be lifted until a compliant trackbase is recorded.

3. Voids in excess of 10 percent shall be filled by the Contractor with non-shrink grout, which shall be applied by a method approved by the Engineer.

4. The top of the track concrete shall be free of depressions that will cause water to pond.

3.08 INSTALLATION

A. Install RT assemblies and DF fasteners in accordance with the following requirements and the approved Contractor's work plan specified herein.

B. Rail and fasteners shall be clean and free of all dirt, mortar, and other substances.

C. Fasteners shall be located directly across from each other on opposite rails at the indicated spacing and tolerances.

D. Lateral adjustment of fasteners is exclusively for future BART maintenance activities. The Contractor shall not use more than plus or minus 1/8 inch of lateral adjustment during construction and defect repair.

E. All fastener components shall be installed to ensure the field side of the rail base and shoulder insulator will be tight against the outside shoulder.

F. Support Prior to and During Concreting:

1. The installation support method shall ensure, prior to concreting, that track is adequately supported at the designed vertical and horizontal alignment by supports specifically manufactured for this purpose. The supports shall be spaced, at a maximum, on ten feet centers and be fixed in location in all directions.

2. The track shall be supported for not less than 100 feet beyond a track section being concreted and in such a manner that will ensure that the track section will not be stressed.

3. The track shall be held to gage and the correct alignment, level, and cant by the supports.

4. The supports shall be capable of withstanding all applied load without any detrimental effects.

5. The supports shall be capable of withstanding thermal expansion and contraction loads, and effects of construction personnel, tools, and equipment that the Contractor uses prior to and during concrete placement.

6. The supports shall have rail-clamping devices and be fabricated from at least three inch by four inch by 3/8 inch thick hollow tube section or equivalent sections approved by the Engineer.

7. Each support shall, as a minimum, provide the following to the assembled track prior to and during concreting:

   a. Hold both rails to the required gage, grade, surface, crosslevel, alignment and cant.

   b. Allow the track to be adjusted by provision of threaded screws or similar continuous means of incremental adjustment.

   c. Be supported directly on to the support structure. The use of precast concrete, or similar, supports for the gage supports may be permitted under the superelevated rail on curves if the method is included in the approved work plan.

   d. Be removable without disturbing the track.

8. The supports shall not be removed until the track concrete has attained a compressive strength of at least 2000 psi.

9. The portion of the gage supports that will be temporarily concreted in shall be coated/protected using the approved method

10. All holes left by the gage supports in the trackbase after concreting shall be cleaned, prepared, and filled by an approved non-shrink cementitious grout. The surface finish of the grout shall be to the same standard of surface finish as that of the finished trackbase.

G. Resilient Tie Track:

1. Resilient tie track shall not be shimmed more than 1 inch for repair of surface and crosslevel defects.

2. Rubber boots, resilient block pads, and lateral adjustment shims shall be secured to the independent concrete blocks that precludes the ingress of deleterious material between the blocks and the boots and provides a tight fit of the boot base to the block pad and the concrete block base.

3. Rubber boots shall be protected during construction by placing a smooth planed timber plank, or similar protection, if work trains operate on the RT track before final adjustment and concreting. Each plank shall be fixed to the underside of the booted block and only removed immediately prior to concreting.

4. Immediately before placing concrete, the rubber boots shall be purged of any water and the drainage holes of the rubber boots sealed using the approved method and material.

H. Direct Fixation Track and DF Special Trackwork:

1. Install polyethylene pads to separate the rail fastener from the concrete surface. The nominal design thickness of the pad shall be 3/8 inch; however, the Contractor may vary the total thickness from 1/8 to 1/2 inch. Not more than two pads shall be used to achieve the total thickness under each rail fastener.

2. Set anchor bolts with calibrated wrenches according to the bolt tension values recommended by the manufacturer. The Contractor shall calibrate the wrenches by tightening, in a device capable of indicating actual bolt tension, not less than three typical bolts from each lot to be installed. Power wrenches shall be adjusted to stall or cutout at the selected tension. If manual torque wrenches are used, the torque indication corresponding to the calibrating tension shall be noted and used in the installation of all bolts of the tested lot. Bolts shall be in tightening motion when torque is measured. All bolts shall be coated with metal preservative.

3. Anchor Bolt Inserts: Install the fastener inserts in accordance with the manufacturer's instructions, and the following requirements.

   a. Inserts shall be cast-in-place with the top of insert flush with the top of the concrete bearing surface.

   b. Handle and install the inserts with care to avoid surface contamination or damage to the epoxy coating. Damaged inserts shall be replaced by the Contractor.

   c. Secure the inserts to the form to prevent any movement during concrete placement.

   d. Upon removal of forms or supports, install a plastic plug in each insert to seal the threaded hole.

END OF SECTION 34 11 24

SECTION 34 11 25

RUNNING RAIL

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Running Rail.

B. Pressure Flash Butt Rail Welding.

C. Thermite Rail Welding.

D. Insulated Rail Joints.

1.02 RELATED SECTIONS

A. Refer to Section 34 05 17, Common Work Results for Trackway, for related requirements.

1.03 MEASUREMENT AND PAYMENT

A. Rail, rail welds, and insulated rail joints will not be measured separately for payment. All costs in connection therewith will be considered as included in the applicable Contract lump sum price or the Contract unit price per linear foot for trackwork of the different types indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. American Railway Engineering and Maintenance of Way Association (AREMA):

1. AREMA Manual

B. American Society for Nondestructive Testing (ASNT):

1. ASNT SNT-TC-1A Recommended Practice No. SNT-C-1A: Personnel Qualification and Certification in Nondestructive Testing

2. ASNT-CP-105 Standard Topical Outlines for Qualification of Nondestructive Testing Personnel

C. American Society for Testing and Materials (ASTM):

1. ASTM E10 Standard Test Method for Brinell Hardness of Metallic Materials

2. ASTM E18 Standard Test Methods for Rockwell Hardness of Metallic Materials

3. ASTM E164 Standard Practice for Contact Ultrasonic Testing of Weldments

4. ASTM E709 Standard Guide for Magnetic Particle Testing

1.05 SUBMITTALS

A. Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Refer to Section 34 05 17, Common Work Results for Trackway, for additional submittal requirements.

C. Provide additional submittals as required herein.

1.06 RUNNING RAIL

A. Only 119RE rail, as shown in the AREMA Manual, shall be used.

B. Product Data, and Test Program Plan. Submit the following for review and approval by the Engineer, prior to rail production in accordance with the approved schedule.

1. Steel manufacture process description for making and casting or teaming the steel.

2. Hydrogen elimination process description for hydrogen elimination.

3. Heat treatment process description for heat treatment of the heat-treated rail, if to be supplied, including the Brinell hardness that will be attained also, proof of the heat-treated rail's ability to consistently meet AREMA rail welding requirements.

4. Alloy rail chemical composition of the alloy rail, if to be supplied, including the Brinell hardness that will be attained. Also, proof of the alloy rail's ability to consistently meet AREMA rail welding requirements.

5. Production records and production test results. Submit the following for review and approval by the engineer at the time of each shipment.

6. Rail test and inspection results for each test and inspection specified by AREMA and herein.

7. Mill certificate containing at least the following data.

    a. Rail section and type.

    b. Heat number.

    c. Number of pieces in each heat.

    d. Chemical analysis.

    e. List of all Brinell hardness readings.

f. Macroetch test results.

g. Ultrasonic test results.

h. Submit a storage procedure covering, as a minimum, the following subjects for storage of running rail at manufacturer's facility:

1) Permanent color marking with different color per type of rail and delivery location.

2) Plan layout of storage area, the number of layers of rails, and segregation of rails by type of rail.

3) Foundation details, materials, and spacing. Confirm adequacy of ground to support the rail stacks.

4) Handling methods in and out of storage, including crane and details of lifting rig.

5) Environmental conditions.

6) Security of stored materials.

7) Inventory control procedures.

1.07 RAIL QUALITY ASSURANCE AND CONTROL

A. Except for modifications, amplifications, deletions, and additions indicated herein, provide running rail in accordance with the requirements of AREMA.

1. Where AREMA states "purchaser" this shall be taken to mean the District.

2. Rail used for the manufacture of special trackwork shall meet the tolerance requirements of the special trackwork manufacturer(s).

B. The Contractor shall establish, implement, and maintain a detailed Quality Plan in conformance with applicable requirements of Section 01 43 00, Quality Assurance, and Section 01 45 00, Quality Control.

C. Qualification of Testing Personnel

1. Personnel performing tests and inspections shall be qualified for such work by virtue of prior experience or training.

2. Personnel performing nondestructive testing shall be qualified and certified in accordance with ANST SNT-TC-1A. Only persons certified for NDT Level I and working under a NDT Level II person or persons certified for NDT Level II shall perform nondestructive testing.

D. Testing Equipment. Testing equipment shall be in good operating condition, of adequate capacity and range, and accurately calibrated. Testing equipment calibration shall be certified and traceable to recognized national standards such as the National Institute of Standards and Technology.

E. Test Program Plan

1. A test program plan shall be prepared identifying the approach for accomplishing each of the specified rail inspections and tests. A detailed narrative shall be prepared for each test and inspection specified herein, describing the test set-up; equipment, and instrumentation that will be used; procedure to be implemented; and the anticipated, as well as, acceptable test results. Drawings showing the relationship of the rail and all significant components of the test equipment shall be included, as necessary, to describe the test set-up and procedure. Pertinent testing drawings included in standard specifications may be referenced in lieu of actual drawings. The test program plan shall include the test sequencing.

2. Equipment specifications, and calibration methods for all testing equipment used to perform rail testing and inspection shall be included in the test program plan. The plan shall indicate the calibration certificates that will be submitted with the test reports.

3. Identity and qualifications of personnel who will perform rail testing and inspection shall be included in the test program plan. Also include certification records for personnel who will perform nondestructive testing.

4. The test plan shall include a description of the testing facilities and a layout of the test equipment that will permit the efficient performance of the testing.

5. The plan shall include the proposed format for reporting test data.

6. The projected schedule for test procedure submittals, test executions, and test results reports submittals shall be included in the test program plan.

7. After approval of the test program plan, any proposed changes shall be approved by the Engineer prior to implementing the change.

F. Test Report

1. A report of test results of each test shall be submitted which includes rail section, rail type, heat number, test name, identity of test sample, test procedure references, specified requirements, actual test results, nonconformances if any, and interpretation of the results. The format for the test report shall be arranged so that the data is presented in an orderly manner.

2. The rail mill’s standard, computer-generated, test reports may be used upon approval by the Engineer. Such reports shall be supplemented, as required, to provide all information, and test and inspection results specified herein.

3. Copies of calibration certificates shall be submitted with the initial test reports. If test equipment is recalibrated while work is being performed on the Contract, calibration certificates shall be submitted for the recalibrated test equipment with the test reports of the first tests performed after recalibration. In lieu of submitting calibration certificates, the manufacturer may maintain the certificates at its facilities available to the Engineer at all times during the performance of the Contract and for a three-year retention period thereafter.

G. The Engineer shall be notified in writing not less than seven Days in advance of dates scheduled for any tests or inspections. The Engineer retains the right to witness the tests.

1.08 PRESSURE FLASH BUTT RAIL WELDING

A. Quality Assurance:

1. When aligning rails in the welding machine, the Contractor, with the prior approval of the Engineer, may pre-determine the gage side and allow differences in width of head to occur on the field side, in accordance with AREMA. The pre-determined gage side shall be marked with red paint 12 inches from each end of the CWR string.

2. The finishing deviation of the rail head running surface and gage face shall be revised to not more than plus 0.020 inch to minus 0.0 inch of the parent section.

3. Each completed weld shall have complete fusion for the entire cross section, and shall be entirely free of cracks.

4. The rail head surface hardness of the weld and heat affected zone shall be as required by AREMA.

B. Qualification of Welding Procedure

1. Prepare a detailed pressure flash butt rail welding procedure specification for the Engineer's approval, describing the step-by-step machine operations and procedures to be employed in making the welds for all rail types and metallurgies to be welded. A complete description of at least the following items and any other essential characteristics shall be included:

   a. Manufacturer and model of the welding machine.

   b. Power source and capacity.

   c. Plan of the welding layout, showing rail feed handling facilities, the welding line and all stations, and the equipment to move the completed strings to the stockpile.

   d. The CWR stockpile detail and configuration, including support to avoid bending the rail or overloading the soil.

   e. Rail cutting equipment and rail end surface preparation.

   f. Platen motion for flashing and upset, voltage and current, and how these relate to welding time.

   g. Forces applied to clamp the rail ends and to upset the rails.

   h. Post weld heating or quenching procedures to meet the hardness requirements for the type of rail.

   i. Weld trimming, grinding, and finishing.

j. Procedure for defective weld cut-out and rewelding.

k. Recording equipment, calibration, operation, and final report format.

l. Names and qualifications of key operating personnel.

2. The Contractor shall qualify the procedure specification at each pressure flash butt rail welding location and for each machine operator in accordance with the following requirements prior to production welding:

a. Make three sample welds of each weld type to be used in the work (standard to standard, special to special, and standard to special). Use weld machine operating variables proposed for production welding; and confirm the values on brush recorder charts or equivalent and qualification records.

b. Qualification Program

1) Inspect all welds in accordance with the requirements of herein.

2) Perform non-destructive ultrasonic testing and magnetic particle testing on each weld in accordance with the requirements herein. Testing shall be performed immediately after the completion of the weld at the location the weld was made.

3) Perform the surface hardness testing on each weld in accordance with the requirements herein.

4) Perform internal metallurgical evaluation on one accepted weld of each type in accordance with the requirements of herein.

5) Prepare a qualification report with the inspection and testing data, and evaluation of the data, and a final definition of the welding machine variables, including the quenching/ tempering procedures.

C. Re-qualification

1. Re-qualification is required for fixed welding plants if the welding machine is moved; or if any of the operating variables of the procedure specification are changed.

2. Re-qualification is required for fixed and portable welding plants if two consecutive welds or re-welds are rejected.

3. For portable in track welding, re-qualification is required if two consecutive welds or re-welds are rejected.

D. Weld Inspection and Testing

1. All weld qualification and production inspection and testing shall be performed by a qualified independent testing service employed by and at the expense of the Contractor. The testing service and their testing program and procedures will be subject to approval of the Engineer.

2. Submit copy of the Contractor's agreement with the testing service to the Engineer for approval. The agreement shall specify that the testing service is directly responsible to the Engineer; that all subsequent communication between the Testing Services and the Contractor regarding the work under this Contract shall be through the Engineer; and that the agreement shall run for the duration of the Contract and can be terminated only by the Engineer.

3. The testing service shall certify whether or not each weld meets the quality criteria immediately following its inspection, and shall promptly indicate acceptance or rejection marking the tested weld. Written reports shall be submitted to the Engineer within five working Days of testing a weld. The Engineer will forward copies to the Contractor.

4. Personnel performing non-destructive examination (NDE) under this specification shall be certified as Level II in accordance with ASNT SNT-TC-1A for the NDE methods they are to perform.

5. The testing service shall prepare written procedures for all inspections and testing for approval by the Engineer prior to the start of Work. Include a description of the proposed procedure, materials, equipment, safety requirements, and report format.

E. Pressure Flash Butt Rail Welding Weld Testing

1. The weld shall be visually inspected in accordance with approved procedures to check for surface defects such as cracks and to determine conformance with the alignment and finishing tolerances specified herein.

2. Acceptance Criteria

   a. Weld quality shall be in accordance with the requirements herein.

   b. Alignment and finishing shall be in accordance with the requirements of AREMA, as modified herein.

3. Ultrasonic Testing (UT)

   a. Ultrasonic (external pulsating) testing of all welds shall be performed in accordance with ASTM E164.

   b. Calibration

      1) A section of rail shall be used as the calibration standard.

      2) Side drilled holes of 1/16 inch diameter shall be used as calibration reflectors for angle beam testing the head of the rail weld. These holes shall be place at 1/4T, 1/2T, and 3/4T and shall be used to construct a Distance Amplitude Curve (DAC). (T is the thickness of the head along the centerline from the top of the head through the head and web fillet.)

      3) Notches shall be used as calibration reflectors for angle beam testing of the web and the base. The notches may be buttress (square) or U type. A notch shall be placed on both sides of the web section of the weld and shall be used to construct a DAC. The notch depth shall be ten percent of

the thickness of the web; plus 10 percent minus 20 percent of required notch depth. Notches shall be at least 1 inch in length and 1/8 to 1/4 inch in width.

c. Testing Procedures

1) The transducer and wedge combination shall produce an angle of 70 degrees plus or minus two degrees in the test material for the web and base and 45 degrees plus or minus two degrees in the head of the rail. The transducer crystal shall be at least 1/2 inch square. Other angles may be used to further evaluate indications. Transducer frequency shall be 2.25 through 5 MHZ.

2) Scanning shall be at 6db above the primary reference level. The rail weld shall be scanned from the top of the head, side of the head, the web, and the top of the base. Scanning shall be accomplished from both sides of the same face of the weld. The scanning pattern shall allow sound to be passed through the entire volume of the weld. When testing rail configurations other than Tee Rail, scanning patterns shall be developed, in each case, to allow the entire cross section of the weld to be tested.

3) The primary reference level to be used when testing the head section of the rail is the gain setting used to construct the DAC from the side-drilled holes. The gain setting used to construct a three point DAC from the notches shall be the primary reference level when testing the web and base sections of the rail weld.

d. Welds showing a response at any level that is identified as a crack or lack of fusion will not be acceptable.

e. Each weld examined shall be recorded on a report form that includes, as a minimum, the following information:

1) Weld number.

2) Technique sketch.

3) Type of equipment, size of transducer, frequency and angle.

4) Calibration data.

5) Equipment identification information (serial numbers).

6) Defect description - depth, location, size, character.

7) Accepted or rejected.

8) Name of operator and certification level.

9) Date of inspection.

4. Magnetic Particle Testing (MT)

a. The Magnetic particle testing of all welds shall be longitudinal magnetization by the dry powder method in accordance with ASTM E709. The magnetizing equipment shall be either an encircling coil or electro-magnetic yoke meeting the following requirements:

1) DC lift capacity of 40 lbs. and/or:

2) AC lift capacity of 10 lbs. at the maximum pole spacing.

b. Test all weld surfaces including the underside of the rail base.

c. Linear indications are unacceptable.

5. Metallurgical Evaluation

a. Cut each weld sample three inches on each side of the weld and then vertically section each specimen at the longitudinal center line of the rail. Perform the following tests:

1) Macroetch and photograph to show fusion line and heat affected zone.

2) Rockwell “C” hardness shall be measured in accordance with ASTM E18 on the vertical section in the head, web, and base at 1/8 inch intervals through the heat affected zone.

b. Acceptance Criteria

1) The heat affected zone shall be symmetrical about the centerline of the weld.

2) The hardness values converted to Brinell shall conform to requirements herein, and shall be symmetrical about the centerline of the weld.

6. Surface Hardness

a. Test Brinell hardness in accordance with the requirements of ASTM E10.

b. Measure Brinell hardness on the rail head along the top centerline and on the gage surface at the centerline of weld and at 1/2 inch increments each way across the heat affected zones to base metal.

c. Conform with requirements herein.

1.09 THERMITE RAIL WELDING

A. Each thermite rail weld requires a Change Order, approved by the District, in advance of installation, except as specifically provided in the Contract Documents.

1. Poor planning, scheduling, improper rail layouts, field changes or weld failures are unacceptable reasons for exceptions.

2. If a defective thermite rail weld is found, then it shall be replaced using a single thermite rail weld or electric-flash butt welding.

3. If the installation of a short rail is required to replace a defective thermite rail weld, then at least one end of that rail shall be welded using the electric-flash butt welding process. In addition, the replacement weld(s) shall comply with the weld location restrictions provided in this Section.

B. When the Contractor determines thermite rail weld locations, the specific restrictions to thermite rail weld use provided in the Design Criteria shall be observed along with the additional weld location restrictions provided in this Section.

C. Weld Alignment and surface misalignment shall be in accordance with the quality requirements herein for pressure flash butt rail welds.

D. Field weld quality shall meet all of the requirements of AREMA, as modified herein.

E. Finishing Tolerances: Top, side of rail head, web and base, plus 0.010 inch to minus 0 inch of the parent rail section.

F. The rail head hardness of the weld and heat affected zone shall be in accordance with AREMA requirements.

G. Prepare and submit a detailed procedure specification for the Engineer's approval, covering step-by-step procedures to be employed in making field thermite welds for all rail types and metallurgies to be welded. A complete description of at least the following items and any other essential characteristics shall be included.

1. Manufacturer's trade name for welding process.
2. Method used for cutting and cleaning of rail ends.
3. Minimum and maximum gap between rail ends.
4. Method and equipment to be used for maintaining rail gap and alignment during welding.
5. Method and equipment to be used for placing, aligning, and holding the molds during welding.
6. Method used for preheating, including minimum time and minimum temperature.
7. Tapping procedure, including minimum time required to cool weld under the mold insulation.
8. Method used for removing gates and risers and finishing weld suitable for radiographic inspection, including a description of special tools and equipment.
9. Marking standards for kit and materials for the rail size, and types of rail and types of field welds.

H. Qualification of Procedure Specification

1. Qualify the above specification procedure by preparing and testing two qualification test welds for each of the three combinations of rail weld types (standard to standard, special to special, and standard to special) prior to beginning production welding. If different field weld gap type or compromise kits are to be used, then each type must be separately qualified under this procedure. The qualification test welds shall be performed in conformance with the procedure specification above, on short lengths of 119 RE rail out of track, and in the presence of the Engineer. One weld shall be made with minimum gap and one with maximum gap.

2. The qualification test welds shall be inspected and tested in accordance with the following requirements.

    a. Visual Weld Inspection.

    b. Magnetic Particle Testing.

    c. Ultrasonic Weld Testing.

    d. Metallurgical Evaluation.

    e. Surface Hardness.

    f. Weld alignment.

    g. Finish tolerances.

3. The testing service shall prepare and submit a report of all inspections and tests with evaluation and acceptance or rejection for approval of the Engineer.

4. The procedure specification will be considered qualified if all tests and inspections meet or exceed the acceptance requirements. If any test or inspection is failed, the Contractor shall submit and qualify a revised procedure specification in accordance with the requirements herein.

5. Production field welding shall not begin until a procedure specification is qualified in accordance with the requirements specified herein.

6. Re-qualification is required if any of the items herein are changed or if more than two consecutive welds or re-welds are rejected.

I. Qualification of Welding Crew

1. Prior to production welding, each crew, including the foreman or supervisor of that crew, shall prepare a qualification weld in each weld type and rail size at the expense of the Contractor. The weld shall be prepared in accordance with the approved procedure specification and will be witnessed by the Engineer.

2. Qualification weld shall be inspected and tested in accordance with the following requirements.

    a. Visual Weld Inspection.

    b. Magnetic Particle Testing.

    c. Ultrasonic Weld Testing.

    d. Metallurgical Evaluation.

    e. Surface Hardness.

    f. Weld alignment.

    g. Finish tolerances.

3. The test record shall contain names of the crew members, including the foreman or supervisor of that crew, who performed the qualification weld, briefly describing their duties. The test records shall also show results of inspection and testing. Performance qualification records shall be submitted to the Engineer at least 14 calendar Days before starting production welding. Production welding shall not start until qualification test welding records have received the Engineer written approval.

4. Re-qualification is required if any of the items herein are changed or if more than two consecutive welds or re-welds are rejected.

J. Weld Inspection and Testing

1. All field weld qualification and production inspection and testing shall be carried out by a qualified independent testing service at the expense of the Contractor. The testing service and their testing program and procedures shall be subject to approval of the Engineer.

2. The Contractor shall submit a copy of its agreement with the testing service to the Engineer for approval. The agreement shall specify that the testing service is directly responsible to the Engineer, that all subsequent communication between the testing service and the Contractor, regarding the work under this Contract, shall be through the Engineer, and that the agreement shall run for the duration of the Contract and can be terminated only by the Engineer.

3. The testing service shall certify whether or not each weld meets the quality criteria immediately following its inspection, and shall indicate promptly acceptance or rejection marking the tested weld. Written reports shall be submitted to the Engineer within five working Days of testing a weld. The Engineer will forward copies to the Contractor.

4. Personnel performing non-destructive examination (NDE) under this specification shall be certified as Level II in accordance with ASNT-SNT-TC-1A for the NDE methods they are to perform.

5. The testing service shall prepare written procedures for all inspections and testing for approval by the Engineer prior to the start of Work. Include a description of the proposed procedure, materials, equipment, safety requirements, and report format.

K. The weld shall be visually inspected in accordance with approved procedures to check for surface defects such as cracks and to determine conformance with the alignment and finishing tolerances herein.

L. Acceptance Criteria

1. Weld Quality shall be in accordance with the requirements herein.

2. Alignment shall be in accordance with the requirements herein.

3. Finishing shall be in accordance with the requirements herein.

M. Magnetic Particle Testing (MT)

1. Magnetic particle testing shall be by the dry powder method in accordance with ASTM designation E709. The magnetizing equipment shall be an electro-magnetic yoke meeting the following requirements.

    a. DC lift capacity of 40 lbs.; and

    b. AC lift capacity of 10 lbs. at the maximum pole spacing.

2. Test all weld surfaces except the underside of the rail base. Magnetization shall be in two directions on each inspected surface.

3. Acceptance Criteria

    a. Only indications greater than 1/16 inch are relevant.

    b. Linear indications that have a length more than three times the width.

    c. Relevant linear indications are unacceptable.

N. Ultrasonic Testing (UT)

1. Ultrasonic (external pulsating) testing of field welds shall be performed in accordance with ASTM E164.

2. Calibration

    a. A section of welded rail at least 12 inches in length with the thermite weld in the center shall be used as the calibration standard. (The side drilled holes and notches shall be located adjacent to the thermite weld material).

    b. Side drilled holes of 3/32 inch in diameter shall be used as calibration reflectors for angle beam testing the head of the rail weld. These holes shall be placed at 1/4T, 1/2T, and 3/4T and shall be used to construct a Distance Amplitude Curve (DAC). (T is the thickness of the head along the centerline from the top of the head through the head and web fillet.)

    c. Notches shall be employed as calibration reflectors for angle beam testing of the web and the base. The notches may be buttress (square) or U type. A notch shall be placed on both sides of the web section of the weld and shall be used to construct a DAC. The notch depth shall be 10 percent of the thickness of the web; plus 10 percent, minus 20 percent of required notch depth. Notches shall be at least one inch in length and 1/8 to 1/4 inch in width.

    d. The sound beam shall pass through the thermite weld during calibration.

3. Testing Procedures

    a. The transducer and wedge combination shall produce an angle of 70 degrees, plus or minus two degrees in the test material for the web and base, and 45 degrees plus or minus two degrees in the head of the rail. The transducer crystal shall be at least 1/2 inch square. Other angles may be used to further evaluate indications. Transducer frequency shall be in the range of 2.25 through 5 MHZ.

    b. Scanning shall be at 6db above the primary reference level. The rail weld shall be scanned from the top of the head, side of the head, the web, and the top of the base. Scanning shall be accomplished from both sides of the same face of the weld. The scanning pattern shall allow sound to be passed through the entire volume of the weld.

    c. The primary reference level to be used when testing the head section of the rail is the gain setting used to construct the DAC from the side drilled holes. The gain setting used to construct a three point DAC from the notches shall be the primary reference level when testing the web and base sections of the rail weld.

4. Acceptance Criteria

    a. Welds showing a response at any level that is identified as a crack, shrinkage, or lack of fusion will not be acceptable.

    b. Welds showing a response that is less than 50 percent of the primary reference level will be acceptable.

    c. Welds showing a response greater than 50 percent, but which do not exceed the primary reference level are acceptable, providing that all of the following requirements apply.

        1) The defects are evaluated as slag or porosity.

        2) The largest defect does not exceed 0.180 inch in its largest dimension.

        3) The total of the defects do not exceed 0.09 square inch.

        4) The sum of the greatest dimension of defects in a line does not exceed 3/8 inch and individual defects are separated by 1/8 inch or more.

    d. Welds showing a response that exceeds the primary reference level will not be acceptable.

5. Each weld examined shall be recorded on a report form that includes as a minimum the following information.

    a. Weld number

    b. Technique sketch

    c. Type of equipment - size of transducer - frequency – angle

    d. Calibration data

    e. Equipment identification information (serial numbers)

f. Defect description - depth, location, size, character

g. Accepted or rejected

h. Name of operator and certification level

i. Date of inspection

O. Metallurgical Evaluation

1. Cut each weld sample three inches on each side of the weld, and then vertically section each specimen to the longitudinal center line of the rail for the following tests.

   a. Macroetch and photograph to show fusion line and heat affected zone.

   b. Rockwell “C” hardness shall be measured along the center line of head, web, and base at 1/8 inch intervals through the heat affected zone. Each completed weld shall have complete fusion for the entire cross section, and shall be entirely free of cracks.

2. Acceptance Criteria

   a. The heat affected zone shall be symmetrical about the centerline of the weld.

   b. The hardness values converted to Brinell shall conform to the requirements herein, and shall be symmetrical about the centerline of the weld.

P. Surface Hardness

1. Test Brinell Hardness in accordance with the requirements of ASTM E10.

2. Measure Brinell hardness on the rail head along the top centerline and on the gage surface at the centerline of weld and at 1/2 inch increments each way across the heat affected zones to base metal.

3. Conform with requirements herein.

1.10 INSULATED RAIL JOINTS

A. Definitions

1. Bonded Insulated Joint: A rail joint that electrically isolates joined rails and is permanently glued or bonded to the rails.

2. Bonded Insulated Joint Plug: A section of rail including a bonded insulated rail joint that has been assembled by the manufacturer, prior to shipment to the construction site.

3. Field Bonded Insulated Joint: A bonded insulated joint assembled in the field by the Contractor.

4. Temporary Insulated Joint: An insulated rail joint temporarily installed to electrically isolate the Contractor's work area from the District's existing operating system to provide protection from stray currents.

B. All design qualification and production testing shall be performed by an approved independent laboratory that is staffed, equipped, and experienced to perform the specified tests, approved by the Engineer, in advance of any testing.

C. Insulated joint tolerances shall comply with the following requirements.

1. Fishing Height: Within plus or minus 1/64 inch of the dimension shown on the approved Drawings.

2. Straightness: All portions of the joint bars adjacent to the rail shall be straight within a tolerance of plus or minus 1/32 inch, measured with a 36-inch straight edge.

3. Rail End Squareness: Variation in squareness of not more than 1/32 inch.

4. Alignment Tolerances

   a. Alignment: Alignment of rail shall be performed on the head of the rail, as follows.

      1) Vertical alignment shall provide for a flat running surface. Any difference of height of the rails shall be in the base.

      2) Horizontal alignment shall be accomplished in such a manner that any differences in the width of heads of rail shall occur on the field side.

   b. Surface Misalignment Tolerance

      1) Combined vertical offset and crown camber shall not exceed 0.040 inch per foot.

      2) Combined vertical offset and dip camber shall not exceed 0.010 inch per foot.

   c. Combined horizontal offset and horizontal kink chamber shall not exceed 0.040 inch per foot at ambient temperature.

5. The end posts on insulated rail joints shall not be less than 3 inches of a tie, direct fixation pad, or rail fastener.

D. Installation procedure and bolt tension shall be as specified by the product manufacturer.

E. Furnish bonded insulated rail joints complete with bars, 3/8 inch end posts, bushings, pin bolts, collars, and adhesive as recommended by the manufacturer.

F. Rail ends at bonded insulated rail joints shall be end hardened in accordance with the AREMA Manual, Supplementary Requirements Sl, End Hardening, and as required herein.

G. Field-bonded insulated joints are not allowed.

H. Following approval of the Shop Drawings and installation procedure by the Engineer, test three bonded insulated joints as specified herein. The Engineer may accept certification from an independent testing laboratory that similar joints have passed an equivalent testing program in lieu of the testing program specified herein, if test was performed within six months of the submittal date.

I. Longitudinal Compression Test

1. Test Preparation

    a. Assemble one bonded insulated rail joint complete, on two pieces of 119 RE rail each two feet long.

    b. Saw joint the assembly in half where rails are butted together, at right angles to centroid of the rail.

    c. Ensure that sawing does not overheat and damage the bonding adhesive.

    d. Affix a device that will confine the reaction at the sawn end to the face of the joint bars when a compressive load is applied at the centroid of the rail at the opposite end.

2. Test Method

    a. Apply test loads in increments of 25,000 pounds, maintaining each increment until longitudinal deflection of the rail ceases before increasing the load to the next increment.

    b. Increase the load in increments until a total load of 650,000 pounds is attained or failure occurs.

    c. At each increment of loading, measure and record the load, and the differential movement of rail and joint bars, to the nearest 0.001 inch.

3. Acceptance Criteria

    a. There shall be no indication of slippage of the rail joint before the total test load reaches 650,000 pounds.

    b. The difference between original position of the joint bar and the rail and the final position thereof after the final test load has been released shall be not more than 1/32 inch.

J. Rolling Loading Test

1. Test Preparation: Mount the second bonded insulated rail joint on a 33-inch stroke rolling load test machine and support on 36-inch centers; center the joint as indicated in Figure 5.

2. Test Method: Apply a 44,000 pound load on the rail for 2,000,000 cycles. Measure and record the deflection at rail centerline to the nearest 0.001 inch when the wheel load is over points A and B for every 500,000 cycles.

3. Alternative Test Methods: Alternative test methods may be submitted, which develop equivalent bending moments throughout the length of the joint bar, for approval by the Engineer.

4. Acceptance Criteria After 2,000,000 Cycles

    a. There shall be no evidence of failure by bending of bonded insulated rail joint.

    b. Deflection exhibited by bonded insulated rail joint shall not exceed 0.065 inch.

K. Electrical Resistance Test

1. Test Method: Fully assemble a third bonded insulated rail joint in accordance with manufacturer's recommendation on two lengths of 119 RE rail, one 24 inches in length, the other 42 inches in length, for an electrical resistance test. During the fabrication, maintain a gap of 3/16 inch between the rail ends with the end post. Support both rails on an electrically non-conducting material.

2. Acceptance Criteria: The acceptance criteria for the 500 V dc Megger Test and the 2.2 kV ac Hypot Test shall be as follows: The minimum resistance for the 500 V dc Megger Test shall be 100 megohms. The joint shall not show any indication of failure when the test is performed.

L. Bonded Insulated Joint Qualification Failure: Failure of the proposed design to satisfy the requirements of the specified tests shall require redesign of the bonded insulated joint to correct the cause of such failure and retesting.

M. Approval

1. All qualification tests conducted on bonded insulated joints shall be successfully completed to the written approval of the Engineer prior to fabrication of any bonded insulated joint.

2. The Engineer may accept Certificates of Compliance that bonded insulated joints of identical design have successfully completed these tests, if test was performed within 6 months of submittal date.

N. Temporary Insulated Rail Joints

1. Temporary insulated rail joints shall be installed as indicated on the Contract Drawings.

2. Bolt Holes

    a. Bolt holes shall be drilled in accordance with herein specified requirements.

    b. Drill only the two holes furthest from each rail end for a total of four holes. Omit track bolts on the holes closest to the rail ends.

3. Before assembly, all contact metal surfaces shall be painted with insulating enamel as specified in the Contract Specifications.

4. Remove temporary insulated rail joints and field weld as required. Field welding shall meet all herein specified requirements.

5. The remaining unused bolt holes at temporary insulated joint locations shall remain in track provided they meet all other herein specified requirements.

6. All temporary insulated rail joints shall be removed prior to the completion of the project and the execution of any retentions.

1.11 PACKAGING, LOADING, SHIPPING, AND HANDLING

A. Rail

1. Bumping and striking the rail during handling or laying will not be permitted. Nicked or gouged rail shall be rejected or repaired as determined by the Engineer.

2. Continuous welded rail shall be unloaded and placed on ties or structures with rollers or other devices approved by the Engineer, which shall prevent damage to the rail, ties, and structure. The bottom of the rail, fastener assemblies, and all bearing surfaces shall be broom cleaned before rail is laid.

3. Rail shall not be covered in dirt and not be submersed in water. Rail damaged by mishandling or allowed to corrode, shall be replaced.

B. Insulated Rail Joints

1. All containers shall be clearly marked with the following: identification of item contained, manufacturer’s name, shipping date, number of pieces, designation, and gross weight.

2. Handle all fasteners in a manner that will prevent damage during packaging, loading and transporting.

3. Pack insulated rail joints separately in units convenient for handling. Assemblies shall be packed in weatherproof wooden, plastic or metal containers, banded on pallets for forklift handling.

4. All Insulated Rail Joint shipments shall be adequately prepared to preclude damage during shipment.

PART 2 – PRODUCTS

2.01 DISTRICT-FURNISHED MATERIALS

A. Refer to Section 01 64 13, District-Furnished Materials and Equipment, of the Contract Specifications for description and quantity of District-furnished materials.

2.02 CONTRACTOR-FURNISHED MATERIALS

A. All products, tools, materials, equipment and labor required to complete all aspects of the work shall be furnished by the Contractor.

2.03 RUNNING RAIL

A. Provide only new 119 RE rail section conforming with the dimensional requirements provided in AREMA.

B. Rail Types

1. Use fully heat-treated carbon steel tee rail, surface heat-treated carbon steel tee rail, on-line-hardened carbon steel tee rail, or high-strength alloy steel tee rail, with a minimum hardness of 365 BHN, with the supplied rail not varying more than plus or minus 10 BHN, but in no case less than 365 BHN. All rail shall be the same rail type and metallurgy throughout.

2. All rail shall be capable of being electric flash butt welded and thermite welded in accordance with AREMA rail welding requirements using standard materials, equipment and techniques. Rail shall be able to consistently meet AREMA rail welding requirements when electric flash butt and thermite welding to other rail types and metallurgies.

C. All rail shall be manufactured in accordance with AREMA, except as provided herein.

D. Rail Lengths

1. Standard rail lengths shall be 70 to 83 feet, when corrected to a temperature of 60 degrees Fahrenheit.

2. Short rails, as short as 39 feet, shall not exceed 25 percent of the total net tonnage accepted for each rail type. The use of short rails shall be limited to the manufacture of special trackwork, insulated rail joint plugs, sidings, yards, spurs and storage tracks. Short rails shall not be used in main line tracks.

E. Furnish rails with blank rail ends, unless otherwise specified in the Contract Specifications.

F. Stamp and brand rails in accordance with the AREMA.

G. Rail Cutting Cut rails square and clean by means of rail saws, or abrasive cutting wheels. Torch cutting is prohibited.

H. Rail shall be roller-straightened.

I. Rails failing to meet the requirements of these Specifications shall be reworked, retreated, cut-back or rejected in accordance with the AREMA, as modified herein.

2.04 PRESSURE FLASH BUTT RAIL WELDING

A. All welds shall be made with electric flash butt welding machines capable of producing welds that meet the quality requirements specified herein, and the following requirements.

1. The welding machine shall have the capacity to forge the rail weld to full refusal.
2. Automatic recording equipment shall be used to monitor and record the significant welding parameters, including the following information:
    a. Voltage.
    b. Current impulses.
    c. Platen movement during flashing and forging.
3. Equipment and procedures required to quench rail to conform with the hardness requirements and post heating if necessary to avoid excessive hardness of any rail.
4. Equipment to shear excess flash close to the shape of 119 RE rail.

2.05 THERMITE RAIL WELD KITS

A. Provide a kit of materials, equipment, tools, and procedures that are qualified as provided herein, and conform with the following requirements.

1. Use factory made preformed molds.
2. Use external preheat prior to welding.
3. Use an alignment jig to set and maintain horizontal and vertical alignment during welding.
4. Use a rail puller/expander to set and maintain the proper rail gap when joining CWR strings.
5. Provide positive identification on each kit of the rail size and type, and the expiration date of the material’s shelf life.

2.06 INSULATED RAIL JOINTS

A. Provide Allegheny or Portec bonded toeless insulated rail joints or equal for insulated joint plugs, designed for six bolts, using huck bolts, with 3/8 inch end post components.

B. For temporary insulated rail joints provide Allegheny or Portec toeless poly insulated rail joints, designed for six track bolts, including track bolts, track bolt plates and 3/8 inch end post components or equal. All nuts shall be located on the field side. Fiberglass insulation shall not be used.

2.07 GENERAL PRODUCTION

A. Production of rail, rail welds and insulated rail joints prior to the Engineer's review and approval is prohibited.

B. Manufacture all rail, rail welds and insulated rail joints materials using the same methods used to produce qualification test pieces.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install rail, rail welds and insulated rail joints in accordance with the respective manufacturer's recommended installation instructions and procedures and as provided, except as modified herein.

B. Install rail, rail welds and insulated rail joints in accordance with the requirements of Section 34 05 17, Common Work Results for Trackway.

3.02 RAIL

A. Install rail as provided by the AREMA Manual, except as modified herein.

B. Cut rails square and clean by means of rail saws or abrasive cutting wheels. Torch cutting is prohibited.

C. Rail branding at reinforcing bar locations and within one foot eight inches of rail ends at joint locations shall be ground smooth. All excess material at rail ends shall be ground off with no resulting beveling.

D. Rail Drilling:

1. Drill the ends of rails where standard rail joints are to be installed as indicated. Rail drilling shall conform to the requirements specified herein, for hole size, location, method, and quality. Each drilled rail end shall have three holes to accommodate a 36-inch, six-hole joint bar. Punching of holes in the rail is prohibited.

2. Rail with drilled ends shall be beveled in accordance with the AREMA.

3. All holes drilled in the rail shall be drilled using an automatic feed rail drill in accordance with the rail drill manufacturer's operating instructions.

4. All holes drilled in the rail, greater than 1/2 inch in diameter, shall be drilled using a broach type bit. Dull broaches or bits shall not be used.

5. Rail/cutting surface interface shall be flooded with a cutting fluid adequate to prevent over heating of the rail. Holes not properly drilled or if bluing of the rail or cuttings occurs shall be rejected.

6. Rail drilling shall be performed so as not to cause mechanical or metallurgical damage to the rail.

7. Holes drilled in the rail shall be circular, perpendicular to the web of the rail, and drilled to the proper dimension.

8. Except for rail joints as otherwise required, all holes shall be drilled through the neutral axis of the rail (3.124 inches above the bottom of the base for 119 RE rail).

9. Where rail is drilled to allow for bolt to pass through the rail, the size of the hole shall be between 1/8 inch and 1/16 larger than the diameter of the bolt to be used, unless otherwise required.

10. Except as provided herein, the diameter of all holes drilled in the rail shall be plus or minus 1/16 inch of the proper dimension.

11. The variation in location of holes drilled in the rail shall be plus or minus 1/16 inch.

12. Entrance and exit sides of all holes drilled in the rail shall be chamfered 1/32 inch (plus or minus 1/64 inch) at a 45 degree angle (plus or minus five degrees).

13. No part of holes drilled in the rail shall be closer than one inch to rail welds.

14. No part of holes drilled in the rail shall be closer than five inches to another hole.

15. Rail that has unnecessary or improperly drilled holes, or locations where train control or traction power bonds are removed or no longer used shall be replaced.

16. Rail drilling for bonding, within special trackwork, shall be performed at the special trackwork manufacturers facility.

E. Replacement Rails:

1. The minimum rail length used as replacement shall be 15 feet and shall be installed to minimize the number of welds and/or rail joints.

2. All repairs shall meet all requirements specified herein.

F. CWR:

1. Construct CWR only using the flash-but pressure welding process, Thermite rail welding of running rail is not permitted except as approved by the Engineer.

3.03 PRESSURE FLASH BUTT RAIL WELDING

A. All rails in a string shall be positioned with the rail heat numbers on the same side.

B. All welding shall be performed by an operator trained and certified by the manufacturer of the welding equipment.

C. The Contractor shall make suitable notations on the charts to identify each weld and reweld; lead rail heat number, rail letter and ingot number; welding machine and string number for each CWR string. Corresponding string numbers shall be painted on the gage side of the web on the lead rail for each CWR string with aluminum paint. Upon daily completion of the work, the Recorder Charts shall be suitably identified by the Contractor and submitted to the Engineer for permanent record.

D. If the gage side of a CWR string is pre-determined as specified herein, the gage side shall be marked with red paint 12 inches from each end.

E. Rail Cutting: All rail cutting shall be square and clean by means of rail saws or abrasive cutting disks. When cutting out a defective weld, remove the heat affected zone on both sides of the weld. Oxy-fuel flame cutting is prohibited.

F. Air quenching is permitted when welding special rails to meet the hardness requirements herein specified.

G. No rail drilling is permitted for handling CWR.

H. Both ends of each CWR string shall be marked with weather-resistant paint at least 12 inches from the rail end with the following information:

1. String number
2. Length
3. Type of rail
4. Pre-determined gage side

I. Prepare and submit the following daily reports and records:

1. Figure 1 - CWR String Report, attached herein
2. Figure 2 - Rail Identification Tally, attached herein
3. Welding Machine Recorder Charts

J. Production Inspection and Testing

1. Inspect every rail end in accordance with the new rail tolerances specified herein, and for any surface or interior defect on the rail end.
2. Non-conforming rail ends shall be cut back until acceptable.
3. Inspect every weld in accordance with the requirements herein.
4. Compare recorder charts of production welds with the qualification chart. Reject welds where the production welding variables are not within the qualified range.

5. UT and MT Test every weld in accordance with the requirements herein.

6. Rejected welds shall be cut out, rewelded, and retested.

3.04 THERMITE RAIL WELDING

A. All welding shall be performed under the direct supervision of a qualified and experienced welding foreman or supervisor. In addition, a manufacturer's representative, experienced in thermite welding, shall be present at the job site and shall witness the performance of at least the first ten acceptable thermite field welds.

B. The rails to be welded shall be cleaned of all grease, oil, dirt, loose scale, and moisture to a minimum of six inches back from the rail ends, including all of the rail surface, by use of a wire brush, to completely remove all dirt and loose oxide, and by use of oxy-fuel torch to a minimum temperature of 250 degrees Fahrenheit to remove any grease, oil, or moisture. The face of the rail ends shall be aligned and arranged at right angles and cut by using a power-actuated saw, or abrasive rail cutting machine, and further cleaned to remove all scale and rust by use of a power actuated grinder with abrasive wheel for two inches on each side of the weld. Rail ends shall show no steel defects, dents, or porosity before welding.

C. The minimum and maximum gap shall be in accordance with the qualified procedure specification for the type of thermite weld being made, and as provided by the equipment manufacturer. The measurements shall be made with go or no-go gauges made of the specified dimensions for the thermite process used. The gap shall be adjusted if under the minimum or over the maximum specified gap.

D. The ends of the rails to be welded shall be properly gapped and aligned to produce a weld that will conform to the specified alignment tolerances. The rail gap and alignment shall be held by a hydraulic rail puller/expander and alignment jig without change during the complete field welding cycle.

E. No holes will be permitted within 36 inches of the ends of the rail to be welded.

F. The rail ends shall be preheated, prior to welding, to a sufficient temperature, and for sufficient time, to ensure full fusion of the weld metal to the rail ends without cracking of the rail or weld.

G. The molds shall be left in place after tapping for sufficient time to permit complete solidification of the molten metal and proper slow cooling to prevent cracking and provide a complete weld with proper hardness and ductility.

H. The weld shall be finished with a rail mounted rail head grinder specifically designed for the work. The balance of the rail section shall be finished with a hand-held grinder as required to remove notches, gouges, visible cracks and other defects. All grinding shall blend to the parent rail section and shall not overheat the steel. Heavy grinding shall be completed while the steel is still hot from welding. Weld reinforcement shall be contoured smoothly to the parent metal to facilitate the performance and interpretation of non-destructive examination.

I. Welding shall not be performed during rain, drizzle, or other inclement weather.

J. During the setting up and actual welding, other work that would in any way move, vibrate, or otherwise interfere with the welding outcome shall be prohibited. Necessary precautions shall be taken to prevent disturbing the weld immediately after the pour when working adjacent to a grade crossing.

K. Protect thermite kit materials from damage and environmental exposure. Store materials under temperature and humidity conditions as recommended by the manufacturer. Do not use materials or molds whose packaging is wet or damaged.

L. Perform cutting of rails as follows:

1. Cut rails so that field welds are midway between cross ties or rail fasteners.

2. Cut rails square and clean by using rail saws or abrasive cutting disks only. Do not flame cut rails. A deviation from square of more than 1/32 of an inch will not be accepted.

3. After cutting, all edges of the cut shall be lightly ground with a hand-held grinder to remove any burrs or fins resulting from the saw cut.

M. Each weld shall be given a number in sequence as the welding progresses. The number shall be painted two inches from the finished weld on the field side of the rail. Defective welds that are replaced shall be given a new sequential “R” number. This number shall be recorded in the field welding records. For example, FW 12-R1 is the first reweld of field weld number 12.

N. Field welding records shall be provided by the Contractor. The field welding records shall be continuously maintained to record details of all field welding as follows:

1. Daily for each filed weld performed – Figure 3.

    a. This exhibit shall be signed and dated by the contractors Forman present during the welding and the inspector/tester.

    b. This exhibit shall be maintained on a daily basis, and shall be available for inspection by the Engineer.

2. Within 30 Days of acceptance of trackwork – Figure 4.

    a. This exhibit shall be maintained on a daily basis, and shall be available for inspection by the Engineer.

    b. This exhibit shall include all field welds performed, including those rejected. The reason for rejection shall be noted. Rewelds shall also be noted.

O. Inspect and test welds after the rails have cooled to ambient temperature, and the rail puller and alignment jig are removed.

P. Each weld shall be visually inspected for surface defects such as cracks and inspected in accordance with the requirements herein.

Q. Test each weld in accordance with the requirements specified herein for Magnetic Particle Testing.

R. Test each weld in accordance with the requirements specified herein for Ultrasonic Weld Testing.

S. Test each weld in accordance with the requirements specified herein, Surface Hardness, except test only on the field side of the rail head.

T. Measure each weld for alignment and surface finish as specified herein.

U. Welds rejected during inspection and testing shall be cut out and rewelded if possible, or replaced with at least 15-foot rail welded in its place in accordance with these Specifications.

V. Locate field welds, including those for insulated joint plugs, so that they do not occur at the following locations, including after thermal rail adjustment.

1. Open Track Construction and Track with Restraining Rails.

    a. Within eight feet of a field weld in the opposite rail.

    b. Within 15 feet of a field weld in the same rail.

    c. Within 36 inches of a pressure flash butt weld or bolt hole.

    d. Within 15 feet from the center of any bolted joint.

    e. On ballasted track within 100 feet of a change of track construction, including ballasted deck structures.

    f. On direct fixation track within 39 feet of a change of track construction.

    g. Within six inches of a tie, direct fixation pad, or rail fastener.

2. Special Trackwork Construction

    a. Within 15 feet of a field weld in the same rail.

    b. Within 36 inches of a pressure flash butt weld or bolt hole.

    c. Within 15 feet from the center of any bolted joint.

    d. Within six inches of a tie, direct fixation pad, or rail fastener.

3.05 INSULATED RAIL JOINTS

A. Only factory bonded insulated rail joint, performed by the manufacturer, shall be used.

B. Insulated Joint Plug Lengths

1. Bonded insulated rail joint plugs shall be no shorter than 15 feet 0 inch long.

2. The shortest segment of rail within bonded insulated rail joint plugs for standard track shall be no shorter than seven feet six inches long.

C. Insulated Joint Plugs shall be manufactured using the correct rail type for the location installed.

D. Any damaged insulated rail joints shall be replaced or repaired according to manufacturers specifications with approval by Engineer.

E. All failed insulated rail joints shall meet all requirements herein.

F. Insulated Joint Location:

1. Insulated joints shall be located such that the end post is no closer than three inches from the nearest tie or rail fastener, including after rail adjustment.

2. Insulated joints not meeting the requirements specified herein will be rejected. The Contractor shall replace all rejected insulated joints. Repaired insulated joints shall meet all herein specified requirements.

3.06 BONDED INSULATED RAIL JOINT MEGGER TESTING

A. At the worksite immediately prior to welding bonded insulated rail plugs to the adjacent rails, perform the following procedure to detect faulty insulated joints. The procedure will detect rail-to-rail shorts and rail-to-joint bar shorts. This test is required in addition to all other required herein.

1. The procedure uses a megohm meter to test rail-to-joint bar impedance and, in some cases, rail-to-rail impedance. The procedure also uses a current injection method for insulated joints where the associated track layout electrically shorts around the joint. The current injection method will check rail-to-rail impedance and isolate which half of an insulated joint bar is shorted to the rail in these areas. The following information specifies the equipment needed, the test procedure, and entering information on the Data Sheet.

2. Equipment

   a. Megohm meter, 250 V or 500 V range;

   b. Frequency-sensitive voltmeter;

   c. Signal generator and leads to attach to rails;

   d. Inductive pick-up coil; and

   e. Jumper that will attach to railhead.

3. Procedure

   a. Insulation shall be tested between each rail and the insulated joint assembly using the megohm meter as follows:

      1) Connect one meter lead to the insulated joint assembly under test by contacting one of the huck bolt collars. Connect the other lead to a second huck bolt collar on the same joint under test. Crank the meter. A

zero reading indicates that good contact has been made and that the test circuit is continuous.

2) Leave one lead attached to the joint assembly huck bolt collar and attach the other lead to one rail section (north or south of the joint). Crank the instrument and record the meter indication in the appropriate place on the data sheet. A reading greater than five M is acceptable.

3) Repeat Step 2) for the second rail section on the other side of the insulated joint.

4) Connect meter leads to rails on either side of insulated joint. Repeat Step 2).

5) If any of the tests fails, perform the following steps:

   a) Connect signal generator and Frequency-Sensitive Voltmeter (FSVM).

   b) Connect jumper to rails on either side of IJ, shorting out IJ.

   c) Set Signal Generator to 12 kHz, plus or minus two kHz and 100 mA (minus 20 mA, plus 50 mA) as measured by FSVM.

   d) If current exceeds 10 percent of Step c), joint fails and is not repaired but replaced, and the replacement joint is tested.

   e) Connect jumper to huck pin on insulated joint bar and to south running rail between IJ and FSVM. If current exceeds 10 percent of Step 3), joint fails and is not repaired but replaced, and the replacement joint is tested.

   f) Move jumper on running rail to other rail. Repeat Step e).

B. Care shall be exercised in unloading and handling material to prevent breaking or bending or in any way damaging the material. Materials shall not be dropped or thrown from cars, but shall be lifted or skidded to the ground or other surface.

C. Minimum Acceptable Resistance 100 megohms prior to installation.

3.07 INSULATED RAIL JOINT HARMON TESTING

A. Perform the following test on bonded insulated rail plugs and bolted insulated rail joints. This test shall be performed immediately after rail welding and thermal rail adjustment and prior to the installation of all traction power negative return power bonding. If the rail is thermally readjusted, all traction power ground return cable shall be removed, prior to testing. This test is required in addition to all others required herein.

B. All testing shall be performed with the adjacent rail and insulated rail joint dry.

C. Testing shall be performed using a Harmon 1501A Insulated Joint Checker (IJC) operated according to the Harmon 1501A IJC Instruction Manual. Other test equipment with equivalent range and accuracy may be used, with advance written approval of the Engineer.

D. All test equipment requiring calibration shall be listed on the appropriate Test Data Form (TDF), showing calibration due date. Out-of-date test equipment for calibration shall not be used.

E. Test Method:

1. Prior to performing the test record the track, location and rail on the TDF.

2. Check that the insulated rail joint is properly installed, the end post is no within three inches of a tie or fastener and is designed for the rail size for which it is installed.

3. Set the FUNCTION SELECTOR SWITCH to the BART position and place the POWER SWITCH to the ON position. The meter should read between 10 and 14 volts. If the meter does not read between 10 and 14 volts, replace batteries or test instrument.

4. Set the FUNCTION SELECTOR SWITCH to the CAL position. Adjust the CALIBRATION ADJ. Knob for a meter reading of 15.

5. Place the POWER SWITCH to the OFF position.

6. Prior to connecting the leads to the rail, sand the rail to bright metal, where test lead connections are to be made.

7. Connect the leads of the Harmon 1501A to the rail, one on each side of the insulated rail joint. Ensure lead connections are tight and make good contact with the running rails.

8. Data evaluation shall consist of comparing the results on the TDF with the requirements of the location being tested.

9. Acceptance shall be based upon the criterion provided by the Engineer.

3.08 UNNECESSARY INSULATED RAIL JOINTS

A. Abandoned Insulated Rail Joints or Insulated Rail Joints that are no longer necessary, located within the limits of the Contract or changes to the Contract, shall be removed

B. Unnecessary Insulated Rail Joints shall not be electrically bonded and shall be removed.

C. The removal of unnecessary Insulated Rail Joints shall meet all herein specified requirements.

END OF SECTION 34 11 25

FIGURE 1 - CWR STRING REPORT

DATE: _____

CONTRACT NO: _____ LOCATION: _____

WELDING CO: _____ SHIFT _____

RAIL SECTION: _____ EXTENSION: _____

STRING NO: _____

STRING LENGTH: _____ Lineal Feet

TOTAL PIECES OF RAIL IN STRING: _____ CONSISTING OF THE FOLLOWING LENGTHS: _____

LENGTH OF CUTOUTS: _____

NO. OF ACCEPTED WELDS: _____

NO. OF REWELDS: _____

TOTAL NO. OF WELDS: _____

STRAIGHTNESS INSPECTOR: _____

MAGNETIC PARTICLE INSPECTOR: _____

ULTRASONIC INSPECTOR: _____

CONTRACTOR WELDING SUPERVISOR: _____

FIGURE 2 - RAIL IDENTIFICATION TALLY

STRING NO:

ITEM	RAISED CHARACTERS	STAMPED CHARACTERS	LENGTH	WELD	REWELD
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					

25					
26					
27					
28					
29					
30					
		1. TOTAL LENGTH*:*			

FIGURE 3 - THERMIT RAIL FIELD WELD RECORD

CONTRACT NUMBER **RAIL FIELD WELD NUMBER**

THERMIT RAIL FIELD WELD DATA		
ITEM	**DESCRIPTION**	**COMPLETED INFORMATION**
1	DATE	
2	TIME	
3	TRACK	
4	LOCATION	
5	RAIL (LEFT or RIGHT)	
6	RAIL TYPE(S)	
7	CONTRACTORS FOREMAN	
8	QUALIFIED WELDER	
9	MANUFACTURER'S REPRESENTATIVE (if present)	
10	WEATHER	
11	RAIL TEMPERATURE	
12	WELD BRAND NAME	

13	RAIL PULLER OR HEATER	YES:		NO:	
14	GAP BEFORE PULING/HEATING				
15	GAP WHEN WELDING				

INSPECTION AND TESTING DATA					
ITEM	**DESCRIPTION**	**COMPLETED INFORMATION**			
16	INSPECTION DATE				
17	INSPECTION TIME				
18	INSPECTORS NAME				
19	INSPECTORS COMPANY				
20	INSPECTION RESULT	ACCEPT:		REJECT:	
21	IF REJECT, INSPECTORS COMMENTS:				
22	TEST DATE				
23	TEST TIME				
24	TESTORS NAME				
25	TESTING COMPANY				
26	TESTING RESULTS	ACCEPT:		REJECT:	
27	IF REJECT, TESTORS COMMENTS:				

CONTRACTORS FOREMAN: **DATE:**

INSPECTOR: **DATE:**

TESTOR: **DATE:**

FIGURE 4 – THERMIT RAIL FIELD WELD SUMMARY RECORD

1) _____ **OF** _____

DISTRICT CONTRACT NUMBER

2) **PAGE** **PAGES**

	WELD NUMBER		RAIL	LOCATION	NOTES
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					

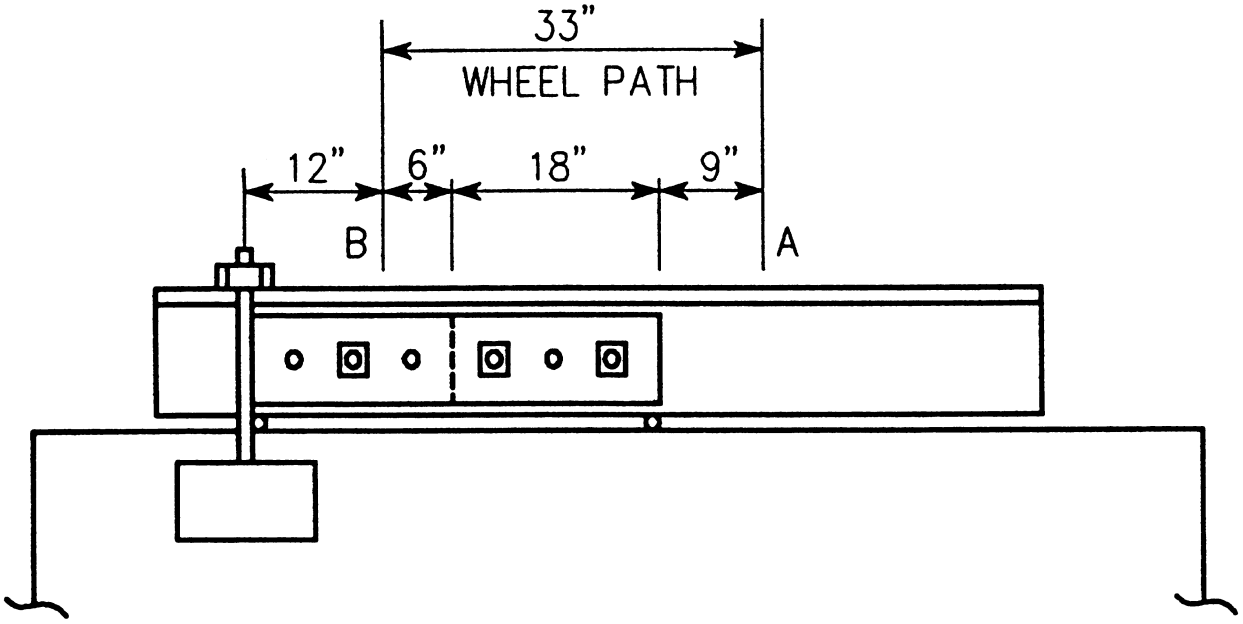


FIGURE 5 - INSULATED RAIL JOINT ROLLING LOAD TEST

SECTION 34 11 27

BALLASTED TRACK

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Subballast.

B. Ballast.

C. Tie placement.

D. Rail installation.

E. Tamping.

F. Surfacing and aligning track.

G. Tire Derived Aggregate (TDA).

1.02 RELATED REQUIREMENTS

A. Refer to Section 34 05 17, Common Work results for Trackway and related requirements.

B. Refer to Section 34 11 93, Track Appurtenances and Accessories, for procurement and related requirements for rail fastener materials.

C. Refer to Section 34 11 31, Concrete Ties, for procurement and related requirements for concrete tie materials.

D. Refer to Section 34 11 25, Running Rail – for related requirements.

1.03 MEASUREMENT AND PAYMENT

A. Ballasted track will not be measured separately for payment. All costs in connection therewith will be considered as included in the applicable Contract lump sum price or the Contract unit price per linear foot for trackwork of the different types indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. American Railway Engineering and Maintenance of Way Association (AREMA):

1. Manual for Railway Engineering

B. American Society for Testing and Materials (ASTM):

1.	ASTM C29/C29M	Standard Test Method for Bulk Density (“Unit Weight”) and Voids in Aggregate
2.	ASTM C88	Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
3.	ASTM C117	Standard Test Method for Materials Finer Than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
4.	ASTM C127	Standard Test Method for Relative Density (Specific Gravity) and Absorption of Coarse Aggregate
5.	ASTM C136/C136M	Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
6.	ASTM C142/C142M	Standard Test Method for Clay Lumps and Friable Particles in Aggregates
7.	ASTM C535	Standard Test Method for Resistance to Degradation of Large Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
8.	ASTM C702/C702M	Standard Practice for Reducing Field Samples of Aggregate to Testing Size
9.	ASTM D75/D75M	Standard Practice for Sampling Aggregates
10.	ASTM D4791	Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate.
11.	ASTM D6270	Standard Practice for use of Scrap Tires in Civil Engineering Applications
12.	ASTM D6938	Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
13.	ASTM D3786/ D3786M	Standard Test Method for Bursting Strength of Textile Fabrics-Diaphragm Bursting Strength Tester Method
14.	ASTM D4533/ D4533M	Standard Test Method for Trapezoid Tearing Strength of Geotextiles
15.	ASTM D4632/ D4632M	Standard Test Method for Grab Breaking Load and Elongation of Geotextiles
16.	ASTM D4833/ D4833M	Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products

17. ASTM D4491/ D4491M — Standard Test Methods for Water Permeability of Geotextiles by Permittivity

18. ASTM D4751 — Standard Test Methods for Water for Determining Apparent Opening Size of a Geotextile

C. State of California, Department of Transportation (Caltrans), Standard Specifications:

1. Section 10-6 — Watering

2. Section 26 — Aggregate Bases

D. State of California, Department of Transportation (Caltrans), Standard Test Methods:

1. Calif. Test 201 — Method of Test for Soil and Aggregate Sample Preparation

2. Calif. Test 202 — Method of Test for Sieve Analysis of Fine and Coarse Aggregates

3. Calif. Test 205 — Method of Test for Determining Percentage of Crushed Particles

4. Calif. Test 216 — Method of Test for Relative Compaction of Untreated and Treated Soils and Aggregates

5. Calif. Test 217 — Method of Test for Sand Equivalent

6. Calif. Test 229 — Method of Test for Durability Index

7. Calif. Test 301 — Method of Test for determining the Resistance “R” Value of Treated and Untreated Bases, Subbases and Basement Soils by the Stabilometer

1.05 SUBMITTALS

A. Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Submit ballast shipping, handling, and placing plan.

C. Provide additional submittals as required herein.

1.06 QUALITY ASSURANCE

A. Track sub grade is the top of subballast. The track sub grade may vary from the design elevations and the line cross sections within the range of plus or minus one half inch.

B. Prior to commencement of trackwork construction, the Contractor will determine the condition of the trackbed for all track types as to line, grade, and cross section, and compaction.

1. Sub grade settlement discovered at this time shall only be corrected by repairing the sub grade as provided herein.

2. Subballast shall be placed and compacted in accordance with the requirements provided herein.

3. Prior to the placement of ballast or other construction on the sub grade the Contractor shall submit to the Engineer a report confirming the readiness of the sub grade.

C. Except for the modifications, amplifications, deletions, and additions indicated herein, construct ballasted track in accordance with the requirements of the AREMA Manual.

D. Ballast is subject to inspection and testing by the Engineer at any time between quarry production and acceptance of track. Ballast that does not conform to these Specifications will be rejected, and the Engineer will notify the Contractor to stop further ballast operations until the defective material has been removed and replaced without additional cost to the District.

1.07 BALLAST TESTING AGENCY

A. Engage an independent testing agency to test the ballast at the quarry source to ensure that the classification, quality, and grading of the ballast at the time of shipment conforms to the specified requirements herein.

1.08 BALLAST SHIPPING AND HANDLING

A. Load only into rail cars or trucks that are in good order, tight enough to prevent leakage and waste of material, and clean and free from rubbish and any substance that may foul the ballast.

B. Handling

1. Handle prepared ballast at the producing plant, during shipment, and at the site so that it is kept clean and free from segregation. Ballast containing any substance that may foul or damage the ballast will be rejected.

2. Do not make repeated passes of equipment over the same level in the stockpile area.

3. Prepare a plan for the proposed transporting from the source, handling, stockpiling, and final distribution and placing of ballast in track; including the location of all stockpiles and the identification, quantity, and condition of all equipment. Submit the plan for the Engineer’s approval prior to shipment.

PART 2 – PRODUCTS

2.01 DISTRICT-FURNISHED MATERIALS

A. Refer to Section 01 64 13, District-Furnished Materials and Equipment, of the Contract Specifications for description and quantity of District-furnished materials.

2.02 CONTRACTOR-FURNISHED MATERIALS

A. All products, tools, materials, equipment and labor required to complete all aspects of the work shall be furnished by the Contractor.

2.03 SUBBALLAST MATERIAL

A. Subballast shall comply with Caltrans Standard Specifications, Section 26, Class 2 Aggregate Base, three-fourths inch maximum grading, with the following additional requirements: Aggregate for subballast shall consist of crushed stone or gravel (reclaimed material will not be allowed), and shall consist of material of which at least 25 percent by weight shall be crushed particles as determined by California Test Method No. 205. Composition of subballast, in percentages by weight, shall conform to the grading shown in Table 1, determined in accordance with California Test Method No. 202.

Table 1 - Percentage Passing Sieves

Sieve Sizes	Maximum
2-inch	0
1-1/2 inch	100
3/4-inch	90-100
No. 4	35-55
No. 30	10-30
No. 200	2-9

B. Subballast shall conform to the additional requirements shown in Table 2.

Table 2 - Additional Requirements

Tests	California Test Method No.	Requirements
Resistance (R-Value)	301	78 min.
Sand Equivalent	217	22 min.
Durability Index	229	35 min.

C. At the time subballast is placed, it shall be free from organic matter and other deleterious substances.

2.04 BALLAST QUALITY REQUIREMENTS

A. Ballast shall be newly acquired from the supplier. Under no circumstances shall used ballast or ballast removed from existing track be used.

B. The amount of deleterious substances present in the prepared ballast shall not exceed the limits shown in Table 3, when performing the following specified tests.

C. Particles having a width to thickness or length to width ratio greater than three shall not exceed five percent by weight of the total as determined by ASTM D4791.

D. The percentage of wear, when tested in the Los Angeles abrasion machine in accordance with ASTM C535, shall not exceed the percentages shown in Table 4.

E. The soundness of the prepared ballast shall be such that, when tested in the sodium sulphate soundness test in accordance with ASTM C88, the weighted average loss shall not exceed five percent after five cycles of the test.

F. Water absorption shall not exceed one percent when tested in accordance with ASTM C127.

G. Determine ballast weight per cubic foot in accordance with ASTM C29/C29M.

H. Ballast samples shall be obtained in accordance with ASTM D75/D75M. Test samples shall be reduced from field samples to testing size in accordance with ASTM C702/C702M.

Table 3 - Deleterious Substances

Test For	Percent By Weight	Test Method
Material Finer than No. 200 Sieve	1	ASTM C117
Clay Lumps and Friable Particles	0.5	ASTM C142/C142M

Table 4 - Percentage Of Wear

TYPE	Percent
Granite	35
Traprock	25
Quartzite	30

2.05 BALLAST GRADING REQUIREMENTS

A. Provide ballast gradation shown in Table 5.

B. Determine the grading of the ballast in accordance with ASTM C136/C136M.

C. Ballast samples shall be obtained in accordance with ASTM D75/D75M. Test samples shall be reduced from field samples to testing size in accordance with ASTM C702/C702M.

Table 5 - Ballast Gradation

Size of Square Sieve Opening	Percent Passing By Weight
2 inches	100
1-1/2 inches	90 to 100
1 inches	25 to 60
3/4 inch	0 to 10

2.06 TIRE DERIVED AGGREGATE (TIRE SHREDS)

A. General: The material shall be made from scrap tires which shall be shredded into the sizes specified herein. Tire shreds shall be free of contaminants such as oil and grease that could leach into the groundwater or create a fire hazard. Tire shreds shall not contain remains of tires that have been subject to a fire. Tire shreds shall have not more than one percent, by weight, of metal fragments which are embedded fully or partially in the rubber. Metal fragments that are partially embedded in rubber shall protrude not more than one-inch from the cut edge of the tire shred on 75 percent of the pieces, by weight, and not more than two inch on 100 percent of the pieces.

B. Type A Tire Shreds: Type A tire shreds shall have a maximum dimension, measured in any direction, of eight inches. Type A tire shreds shall have 100 percent, by weight, passing the four-inch square mesh sieve, a minimum of 50 percent passing the two-inch square mesh sieve, and a maximum of five percent passing the number four sieve.

2.07 GEOTEXTILE FABRIC

A. The geotextile fabric shall have property values expressed in “minimum” or “minimum average roll” values that meet or exceed the values listed below, as determined by the test methods specified below. All Mechanical property values expressed as “average” or “typical” shall exceed the minimum permissible values specified below by not less than 25 percent.

Geotextile Mechanical Property Value	Test Method	Minimum Permissible
Mullen Burst Strength	ASTM D3786/D3786M	290 psi
Trapeziodal Tear Strength	ASTM D4533/D4533M	50 lb.
Grab Tensile Strength (both directions)	ASTM D4632/D4632M	180 lb.
Grab Elongation	ASTM D4632/D4632M	15 percent
Puncture Resistance	ASTM D4833/D4633M	50 lb.
Permeability	ASTM D4491/D4491M	0.001 cm/sec maximum
Apparent Opening Size (AOS)	ASTM D4751	U.S. Std. Sieve number(s) between No. 20 & No. 100

2.08 SOURCE QUALITY CONTROL

A. Subballast material shall be sampled and tested in accordance with the California Test Methods specified herein, to determine compliance with specified requirements. Samples shall be taken from material as delivered to the site, and shall be prepared in accordance with California Test Method No. 201.

B. The Contractor shall establish the ballast quality, grading, and washing requirements at the time of shipment to ensure that the ballast conforms to the requirements herein when installed in trackwork.

C. Tests of ballast at the quarry source conducted by the independent testing agency shall include the following:

1. A test sample not less than 150 pounds shall be taken from a quarry test run of prepared ballast in accordance with the requirements of ASTM D75/D75M.

2. Perform the tests and inspections in accordance with Articles 2.04 and 2.05 herein on the ballast samples.

D. Engineer’s Approval

1. Obtain Engineer’s approval of ballast material prior to commencing delivery of the ballast to the site.

2. If, during ballast installation, the source of ballast changes, the Contractor shall perform tests at the new production site in accordance with these Specifications. The ballast shall have the same classification, quality, and grading as the former ballast used. Delivery to the site shall not commence until the Engineer has approved the new ballast source.

PART 3 – EXECUTION

3.01 INSPECTION

A. The Contractor shall call for an inspection, at least one week in advance, by the Engineer and obtain approval of the prepared sub grade or sub base before proceeding with the subballast course.

B. The sub grade or sub base to receive subballast, immediately prior to spreading, shall conform to the compaction and elevation tolerances indicated for the material involved and shall be free of standing water and loose or extraneous material.

3.02 SUBBALLAST INSTALLATION

A. Subballast course shall be applied over the prepared sub grade or sub base and compacted in accordance with Section 26 of the Caltrans Standard Specifications.

B. Subballast course shall be minimum uniform thickness after compaction of dimensions indicated. Where not indicated, compacted thickness shall be six inches.

C. All compaction expressed in percentages in this Section refers to the maximum dry density of the material as determined by California Test Method No. 216.

D. Aggregate for subballast shall be delivered as uniform mixture of fine and coarse aggregate and shall be spread in layers without segregation.

E. Subballast material shall be free of pockets of large and fine material. Segregated materials shall be remixed until uniform.

F. Subballast material shall be moisture-conditioned to near optimum moisture content in accordance with the applicable requirements of Section 10-6 of the Caltrans Standard Specifications.

G. Subballast six inches and less in thickness may be spread and compacted in one layer. For thickness greater than six inches, the subballast shall be spread and compacted in two or more layers of uniform thickness not greater than six inches each.

H. Relative compaction of each layer of compacted subballast material shall be not less than 95 percent as determined by California Test Method No. 216.

I. Thickness of finished subballast course shall not vary more than one inch from the indicated thickness at any point. Subballast that does not conform to this requirement shall be reshaped or reworked, watered, and re-compacted to achieve compliance with specified requirements.

J. The surface of the finished subballast course at any point shall not vary more than one inch above or below the indicated grade.

3.03 DOCUMENTATION AND PROTECTION OF FACILITIES IN TRACKBED

A. Survey and document the condition of facilities in the trackbed, including buried conduits in the track bed, conduit stub-ups, precast concrete trenches, sub drains and filter beds, cleanouts, ballast screens, and manholes. Incorporate the information in a report and submit to the Engineer prior to starting construction work and the operation of heavy equipment and vehicles on the trackbed.

B. Protect all facilities in, under, or on the trackbed during track construction. Repair all damage to the facilities, at no additional cost to the District, which was caused by the Contractor's operations, and which was not a pre-existing condition as indicated in the Contractor's survey report.

3.04 PRELIMINARY BALLAST LAYER

A. Preparation: Correct all rutting and other damage to the sub grade prior to placing ballast.

B. Installation: A layer of ballast six to eight inches deep shall be placed on the prepared sub-grade or subballast for all main tracks, ready for compacting without further shaping. The ballast shall be compacted with not less than three passes of a vibratory roller of gross weight not less than 5,000 pounds, a drum not less than 58 inches wide and not less than 42 inches in diameter. The vibration frequency shall be between 1,100 and 2,000 vibrations per minute and shall impart a dynamic impact of not less than nine tons. Avoid damage to existing facilities including sub-drains, stub-ups, conduits, and other structures.

C. Ballast Deck Bridges: Install a preliminary ballast layer on main track ballast deck bridges directly over the waterproofing protection boards, taking care not to damage the protection boards and the perforated deck drains.

D. Ballast Finish: The top of the preliminary ballast layer shall be a level, flat plane, uniformly compacted prior to cross tie distribution.

3.05 CROSS TIE DISTRIBUTION

A. Position all ties with a jig in final location and normal to the centerline of track.

B. Position all ties within plus or minus one inch of required spacing as indicated on Contract Drawing, without accumulation.

C. Placing Ties

1. Place ties so the bottom of each tie will bear fully on initial layer of ballast.

2. Alternate the ends of cross ties with contact rail bracket anchor inserts, except at special locations as indicated on the Contract Drawings.

3.06 RAIL INSTALLATION

A. Lay, join and anchor CWR and jointed rail as provided herein.

3.07 TAMPER-LINER MACHINE

A. Provide a production type tamper-liner capable of lifting, lining, and surfacing track and turnouts within the specified track tolerances and with the specified ballast. The machine shall be capable of external control of both line and grade. The machine shall be capable of external control of alignment utilizing a laser guidance system.

B. Each lift of ballast shall be thoroughly tamped, with a squeeze type vibrating tamping machine, from a point 18 inches inside each rail on both sides of the tie to the end of the ties. The ballast shall be packed tight under and around the tie for the length specified. Tamping shall not be permitted at the center of the tie between the above stated limits. Both ends of the tie shall be tamped simultaneously, and tamping inside and outside of the rail shall be performed at the same time.

C. Lift both rails together as uniformly as possible.

D. Operate tamper machine in accordance with the machine manufacturer's printed instructions. Provide a copy of the instructions to the Engineer.

E. Do not operate the machine on tangent tracks unless the laser guidance system is utilized.

F. Tamper operation shall not damage ties. All ties damaged in any fashion by tamping of ballast shall be replaced. Patching or other repairs of ties will not be accepted.

3.08 PRELIMINARY SURFACING AND ALIGNING

A. General

1. Surfacing and/or aligning of the track shall not be performed when the rail temperature is higher than 100 degrees Fahrenheit.

2. Track surfacing and aligning shall be performed by methods which will prevent bending of the rail, straining of the rail joints, and damage to the ties or rail fastening assemblies.

3. All switch and switch machine rods shall be removed prior to tamping. The rods shall be replaced and the switch readjusted, as required herein, when tamping is completed.

B. Control and check the alignment of the track on the preliminary ballast with the necessary alignment and grade stakes.

C. Ballast:

1. Handle, transport, and place ballast to avoid segregation and generation of fines.

2. Place and maintain sufficient ballast in the cribs and shoulders to anchor the cross ties and prevent movement or buckling of the track due to temperature changes or equipment operation.

D. Lifting:

1. Track shall be lifted so that it will be necessary to give it a finishing lift of not less than one inch nor more than two inches to bring it to final grade. Alignment shall be maintained during the lifting operation.

2. Ties that have been pulled loose shall be replaced to proper position, and shall have a bearing against the rail, and shall be secured to the rail.

3. The amount of each lift, including that required for superelevation, shall not exceed four inches nor endanger the horizontal or vertical stability of the track.

3.09 FINAL SURFACING AND ALIGNING

A. A finishing lift and alignment shall be made to bring tracks to the true line and grade within the specified tolerances after completion of the preliminary surfacing and aligning.

3.10 BALLAST REGULATION

A. After final surfacing and aligning is completed, ballast shall be dressed as indicated. The portion of the sub grade outside of the ballast shall be trimmed an even surface sloped for drainage.

3.11 BALLAST CONSOLIDATION

A. Compact ballast with rail mounted equipment specifically designed to dynamically stabilize the track structure through the rail.

B. Dynamic track stabilizer capable of applying stabilizing forces into the track structure at a continuous speed of one half miles per hour. The equipment shall have an operational measuring system that provides for accurate measurement and control of stabilization.

C. The ballast shall be stabilized twice. Once prior to final raise and once after final raise and alignment to finish grade.

3.12 CONTACT RAIL INSTALLATION

A. Contact rail insulator brackets shall not be bolted to the crossties until completion of ballast dressing and consolidation.

B. Ballast shall conform to full section after completion of contact rail installation.

3.13 MANUAL TAMPING

A. No manual tamping shall be performed.

3.14 SPACING AT TIE ENDS

A. Conduit stub-ups, manholes, buried vaults, cableways, foundations, walls, obstructions or other trackway construction shall be at least 12 inches outside of a line created by connecting adjacent tie ends.

B. Additional space shall be provided to ensure 12 inch clearance behind third rail assemblies. Ties or tie layouts shall not be modified to accommodate this requirement.

3.15 TIRE SHRED INSTALLATION

A. Subgrade Preparation: The subgrade that will underlie the tire shred course shall meet the grade tolerance, compaction, and other requirement specified in Section 31 00 00, Earthwork. Install subdrain lines as indicated in Section 33 46 00, Subdrainage.

B. Geotextiles: The tire shred course shall be enclosed in a layer of geotextile as shown on the Contract Drawings. The geotextile shall be unrolled smoothly on the surface to minimize wrinkles and folds. Adjacent lengths of geotextile shall be overlapped a minimum of 18 inches at the ends and sides. The cover material shall be dumped on previously placed cover material or at the edges of the geotextile, and then pushed on to the geotextile. Construction equipment shall not be allowed on the geotextile when the geotextile is covered with less than eight inches of compacted cover material.

C. Placing: The tire shred layer shall be placed in two lifts of approximately equal thickness. Each lift of tire shreds shall be placed over the full width of the section. The tire shreds shall be spread with equipment as needed to obtain a uniform lift thickness. The tire shreds, as spread, shall be well mixed with no pockets of either fine or coarse tire shreds. Segregation of large or fine particles will not be allowed.

D. Shaping and Compacting: Each lift of tire shreds shall be compacted with six passes of a vibratory smooth drum roller with a minimum static weight of 20,000 lb. The completed surface of the tire shred course shall be brought to a condition of uniform stability, compaction, and texture, ensuring no addition of foreign materials. The top surface of the tire shred fill shall be overbuilt to an elevation one inch above the finished elevation shown on the Contract Drawings. A tolerance of one and a half inches below the required grade and cross section will be allowed.

3.16 FIELD QUALITY CONTROL

A. Contractor Testing: Sample ballast at the time of deposit on the trackbed, and perform a minimum of one gradation test and one test on material finer than No. 200 sieve for every 1,000 cubic yards of ballast delivered to the jobsite to ensure uniformity and conformance with the requirements specified herein. Submit a report of the test results to the Engineer.

B. The Engineer may take additional samples of in-place ballast. The Contractor shall assist and cooperate with the Engineer in taking such samples.

C. Any in-place ballast not meeting the requirements herein shall be replaced by the Contractor at no additional cost to the District.

D. Subballast Field Quality Control:

1. Test the relative compaction of each layer of compacted subballast in accordance with California Test Method No. 216.

2. Perform tests in accordance with ASTM D6938 to determine compliance with specified requirements for density and compaction of subballast, and to determine moisture content of the installed subballast.

END OF SECTION 34 11 27

SECTION 34 11 30

EMBEDDED TRACK

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Forms.

B. Work plan.

C. Track concrete.

D. Rails.

1.02 RELATED REQUIREMENTS

A. Refer to Section 34 05 17, Common Work Results for Trackway, for related requirements.

1.03 MEASUREMENT AND PAYMENT

A. Embedded track will not be measured separately for payment. All costs in connection therewith will be considered as included in the applicable Contract lump sum price or the Contract unit price per linear foot for trackwork of the different types indicated in the Bid Schedule of the Bid Form.

1.04 SUBMITTALS

A. Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Work Plans: Submit construction work plans for Embedded Track. Plans shall be prepared and sealed by a civil engineer currently registered in the State of California.

C. Provide additional submittals as required herein.

D. All submittal shall be prepared, reviewed, signed, and sealed by a qualified California Registered Professional Engineer, experienced in the design of the item being submitted. This engineer shall include a certification with each submittal that all Contract requirements are met for the submittal.

1.05 WORK PLAN

A. In addition to the other requirements herein the Contractor shall prepare and submit to the Engineer a separate construction work plan for embedded track in accordance with the track requirements and tolerances specified herein. If the work plan is acceptable, the Engineer will issue permission to proceed with construction.

B. Each work plan shall, at a minimum, include the following items:

1. Step by step construction sequence.
2. Survey control plan.
3. Material handling procedure.
4. Special equipment and tools.
5. Shop Drawings of forms, jigs and supports.
6. Method of protecting any supports to allow removal after concrete installation.
7. Method of treating holes in the concrete created by any temporary supports.
8. Concrete surface and dowel preparation.
9. Methods of protecting existing drainage from deleterious material during construction.
10. Methods of collected and removing washed material, debris and dust.
11. Forming, placing, finishing, and curing of track concrete.
12. Repair procedures for non-conforming concrete.
13. Coordination between the installation of other various track types at interfaces.
14. Repair procedures for deviations in track gage, surface, rail cant, and alignment.
15. Shop drawings of purpose manufactured gauge supports to support track, fasteners and/or rail hold-downs prior to and during concrete placement.
16. CWR handling and installation.
17. CWR adjusting, rail welding, and anchoring to conform to the neutral rail temperature requirements.
18. Field testing and inspection to conform to the quality requirements and tolerances specified herein.
19. Rail boot product information and manufacturers installation instructions.
20. Method of joining rail boot at rail boot joints.

1.06 QUALITY ASSURANCE AND CONTROL

A. Install materials according to manufacturer’s requirements and the requirements specified herein.

PART 2 – PRODUCTS

2.01 DISTRICT-FURNISHED MATERIALS

A. Refer to Section 01 64 13, District-Furnished Materials and Equipment, of the Contract Specifications for description and quantity of District-furnished materials.

2.02 CONTRACTOR-FURNISHED MATERIALS

A. All products, tools, materials, equipment and labor required to complete all aspects of the work shall be furnished by the Contractor, including the following.

B. Provide continuous rubber rail boot as manufactured by Iron Horse Engineering Co., L. B. Foster Co. or equal.

C. Provide L2 X 3 X 1/4 inch continuous nosing strip along flangeway corner.

1. Nosing strip shall be welded as one continuous piece along each rail.

2. Nosing strip shall have integral 1/2 inch X 4 inch concrete anchors, located on six inch minimum centers.

3. Holes, countersinks or screw-type anchors are not acceptable.

D. Rail anchor bolts shall be provided at 36 inch spacing along each rail.

E. Rail Clips, purpose designed for rail hold-down, and anchor bolt locations.

F. Provide other materials as shown on the Contract Drawings.

PART 3 – EXECUTION

3.01 REQUIREMENTS

A. Construct embedded track in accordance with applicable requirements herein and as indicated on the Contract Drawings.

3.02 EXISTING FACILITIES

A. Protect dowels, drainage facilities, and electrical conduits from damage and plugging. Repair promptly damage due to Contractor’s operations.

3.03 FORMS

A. Design and install forms in accordance with Section 03 11 00, Concrete Forming.

3.04 CONCRETE

A. Concrete shall be in accordance with Sections 03 20 00, Concrete Reinforcing, 03 30 00, Cast-In-Place Concrete, and 03 05 15, Portland Cement Concrete.

B. Concrete and concrete reinforcement shall not come into contact with the running rail.

3.05 PRE-POUR SURVEY

A. Immediately prior to pouring track concrete the formwork and supporting jigs shall be surveyed for readiness.

B. The survey shall take place no more than four hours prior to placing track concrete.

C. The survey shall be performed by, or under the direction of, a professional land surveyor or civil engineer currently licensed or registered in the State of California.

D. Measurements shall be taken at each support location and shall include, at a minimum, alignment, surface and elevation and cant of both rails, gage, and crosslevel.

E. No track concrete may be placed prior to repairing any deviations found during the inspection.

F. All measurements shall be recorded and submitted to the Engineer on the same day that the measurements are made.

3.06 RAIL PROTECTION AND TESTING

A. Rail shall be protected for damage, nicks, and cuts.

B. Upon completion, the running surface of the rail shall be cleaned and free of all dirt, mortar, paint and other substances.

C. Rail grinding is not required on embedded track.

D. All rail testing shall be performed prior to placing track concrete.

END OF SECTION 34 11 30

SECTION 34 11 31

CONCRETE TIES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Crossties (CT).

B. Concrete Special Trackwork Ties (SPCT).

1.02 RELATED REQUIREMENTS

A. Refer to Section 34 05 17, Common Work Results for Trackway, for related requirements.

B. Refer to Section 34 11 37, Direct Fixation Fasteners, for additional testing requirements.

1.03 MEASUREMENT AND PAYMENT

A. Concrete ties will not be measured separately for payment. All costs in connection therewith will be considered as included in the applicable Contract lump sum price or the Contract unit price per linear foot for trackwork of the different types indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):

1. AASHTO T277 — Standard Method of Test for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration

B. American Concrete Institute (ACI):

1. ACI 305R — Guide to Hot Weather Concreting

2. ACI 318 — Building Code Requirements for Structural Concrete and Commentary

C. American Railway Engineering and Maintenance of Way Association (AREMA):

1. Manual for Railway Engineering

D. American Society for Testing and Materials (ASTM):

1. ASTM A416/416M — Standard Specification for Low-Relaxation, Seven-Wire Steel Strand for Prestressed Concrete

2.	ASTM A881/A881M	Standard Specification for Steel Wire, Indented, Low-Relaxation for Prestressed Concrete
3.	ASTM A886/A886M	Standard Specification for Steel Strand, Indented, Seven-Wire Stress-Relieved for Prestressed Concrete
4.	ASTM C31/C31M	Standard Practice for Making and Curing Concrete Test Specimens in the Field
5.	ASTM C33/C33M	Standard Specification for Concrete Aggregates
6.	ASTM C39/C39M	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
7.	ASTM C78/C78M	Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
8.	ASTM C94/C94M	Standard Specification for Ready-Mixed Concrete
9.	ASTM C114	Standard Test Methods for Chemical Analysis of Hydraulic Cement
10.	ASTM C150/C150M	Standard Specification for Portland Cement
11.	ASTM C157/C157M	Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete
12.	ASTM C172/C172M	Standard Practice for Sampling Freshly Mixed Concrete
13.	ASTM C227	Standard Test Method for Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method)
14.	ASTM C295/C295M	Standard Guide for Petrographic Examination of Aggregates for Concrete
15.	ASTM C359	Standard Test Method for Early Stiffening of Hydraulic Cement (Mortar Method)
16.	ASTM C490/C470M	Standard Practice for Use of Apparatus for the Determination of Length Change of Hardened Cement Paste, Mortar, and Concrete
17.	ASTM C494/C494M	Standard Specification for Chemical Admixtures for Concrete
18.	ASTM C586	Standard Test Method for Potential Alkali Reactivity of Carbonate Rocks as Concrete Aggregates (Rock-Cylinder Method)
19.	ASTM C617/C617	Standard Practice for Capping Cylindrical Concrete Specimens

20.	ASTM C917	Standard Test Method for Evaluation of Cement Strength Uniformity from a Single Source
21.	ASTM C1017/C1017M	Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete
22.	ASTM C1105	Standard Test Method for Length Change of Concrete Due to Alkali-Carbonate Rock Reaction
23.	ASTM C1260	Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
24.	ASTM D512	Standard Test Methods for Chloride Ion in Water
25.	ASTM D1411	Standard Test Methods for Water-Soluble Chlorides Present as Admixtures in Graded Aggregate Road Mixes

E. Precast/Prestressed Concrete Institute (PCI):

1.	PCI MNL 116	Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products

1.05 SUBMITTALS

A. Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Refer to Section 34 05 17, Common Work Results for Trackway, for additional submittal requirements.

C. Provide additional submittals as required herein.

D. Submit design drawings, material specifications, laboratory test results, and fabrication procedures in sufficient detail to demonstrate conformance or equivalence with the Contract requirements herein.

1.06 CT AND SPCT SUBMITTALS

A. Separate submittals are required for CTs and SPCTs.

B. Submit three samples of CTs and SPCTs to the Engineer, within 90 Days following award of the Contract, of complete all various rail fasteners, including embedded shoulders, spring clips, insulators, tie pads, and contact rail support bracket inserts for review by the Engineer.

C. Submit detailed shop drawings indicating the following:

1. Dimensional details of cross and special trackwork ties showing plan, elevation, and cross sections. Include concrete strength and material specifications.

2. Location and spacing of pre-stressing tendons with specifications and initial pre-stress force.

3. Dimensions and tolerances and location of rail fastening components for rail and rail joints, turnout plates, contact rail support bracket inserts and conduits.

4. Plans and samples to demonstrate conformance with the track tolerance requirements.

5. Requirements for handling, transporting, and stacking of ties.

6. Submit list of sources proposed by the Contractor to obtain materials requiring approval, certifications, or testing.

1.07 CT AND SPCT QUALITY ASSURANCE AND CONTROL

A. Qualifications of Fabricator

1. CTs and SPCTs shall be produced in a plant or production facility by a fabricator who has been regularly and continuously engaged in the manufacture of precast, prestressed concrete products for a minimum of five years. In addition, the fabricator shall have had experience in the fabrication of precast, pre-stressed CTs and SPCTs similar to the ties indicated.

2. Fabricator shall have sufficient production capacity to produce the required number of ties in accordance with the quality requirements and without causing any delay in the work.

3. The fabricator shall furnish certification that all aspects of the yard operation, including materials testing, storage, and handling conform with the quality control requirements herein, and current industry standards as defined in PCI MNL 116.

4. Current certification by PCI throughout the fabrication period will be accepted as evidence of conformance with this requirement.

5. Certification by a qualified, independent consultant or laboratory will also be accepted as evidence of conformance with this requirement. Initial certification shall be based on a plant inspection of yard operations and quality control procedures. The Engineer shall be notified prior to the inspection and may attend. At least two follow-up inspections shall be performed during the production run, and each certificate of conformance submitted to the Engineer.

B. Fabricate CTs and SPCTs within the tolerances indicated and specified. When not indicated or specified, conform to tolerances specified in the AREMA Manual.

C. Maintain the quality of materials, components, and finished products in accordance with the requirements herein. The quality assurance plan for CTs and SPCTs shall include the following elements.

1. Material specifications; certificates of compliance.

2. Formwork.

3. Setting of embedded inserts for running rails and contact rail bracket support.

4. Placing pre-stressing steel tendons. Application of pre-stressing force and transfer details.

5. Proportioning of concrete mix. Mixing, transporting, placing, consolidating, and surface finishing.

6. Curing details.

7. Identification.

8. Quality control production testing procedures and frequency. Inspection procedures.

9. Vendor (sub-supplier) surveillance.

10. Corrective action and disposition of defective or rejected CTs and SPCTs.

11. Delivery protection and handling.

12. Acceptable quality levels and sampling plans.

D. Testing Facilities.

1. All design qualification testing on the cross tie and fastener assembly shall be performed by an approved independent laboratory that is staffed, equipped, and experienced to perform the specified tests.

2. All daily production quality control testing shall be performed in accordance with the approved Test Program Plan.

E. All testing to detect reaction between cement and aggregates and to determine chloride permeability shall be performed by qualified independent laboratories. Laboratories shall conform to the following standards as a minimum.

1. ASTM C295/C295M: A commercial laboratory shall meet the following criteria.

a. It has the equipment listed in Section 6, ASTM C295/C295M.

b. It shall have personnel trained in identifying aggregate types using stereo- and polarizing-light microscopes. The personnel shall have experience in recognizing potential alkali-reactive aggregates.

2. ASTM C1260 or ASTM C1567: The laboratory shall have the equipment listed in ASTM C1260 or ASTM 1567, and have an experienced analytical chemist.

3. ASTM C227: A laboratory shall meet the following requirements.

    a. Have the equipment listed in Section 4;

    b. Have the facilities for control of temperature and humidity described in Section 5:

    c. Have a storage cabinet or room meeting the requirements of Section 7; and

    d. Have personnel experienced in performing such a test. The control of temperature and humidity are very important.

4. ASTM C586: The laboratory shall have the equipment and chemical reagents listed in Section 6.

5. ASTM C1260: A commercial laboratory shall meet the following requirements.

    a. Have a petrographer experienced in the identification of potential alkali-reactive aggregates and in the examination of concrete samples.

    b. Have an experienced analytical chemist.

    c. Have the equipment required to perform all tests required herein.

6. AASHTO T277: The test procedures proposed by the independent testing agency shall be reviewed by a representative from the Construction Technology Laboratories, Inc. (CTL), since CTL originally developed the test, and a CTL representative shall witness all testing.

F. Qualification of Testing Personnel: Personnel shall be qualified by virtue of prior experience or training.

G. Testing Equipment: Testing equipment shall be in good operating condition, of adequate capacity and range, and accurately calibrated. Testing equipment calibration shall be certified and traceable to recognized national standards such as the National Institute of Standards and Technology. Testing equipment shall be calibrated in accordance with the requirements of the approved Quality Assurance Plan.

H. Test Program Plan.

1. A test program plan shall be prepared identifying the approach for accomplishing each of the specified tests. A detailed narrative shall be prepared for each test and inspection specified describing the test set-up; equipment, and instrumentation that will be used; procedure to be implemented; and the anticipated, as well as acceptable test results. Drawings showing all significant components of the test equipment shall be included, as necessary, to describe the test set-up and procedure. Pertinent testing drawings included in standard specifications may be referenced in lieu of actual drawings. The test program plan shall include the test sequencing.

2. Equipment specifications, and calibration methods for all testing equipment used to perform testing and inspection shall be included in the test program plan. The plan shall indicate the calibration certificates that will be submitted with the test reports.

3. Identity, and qualifications of personnel who will perform testing and inspection shall be included in the test program plan. Also include certification records for personnel who will perform nondestructive testing.

4. The test plan shall include a description of the testing facilities and a layout of the test equipment that will permit the efficient performance of the testing.

5. The plan shall include the proposed format for reporting test data.

6. The projected schedule for test procedure submittals, test executions, and test results reports submittals shall be included in the test program plan.

7. After approval of the test program plan, obtain Engineer's written approval of any proposed changes prior to implementing the change.

1.08 PACKAGING, LOADING, SHIPPING, AND HANDLING

A. The Contractor shall submit a stockpile plan to the Engineer for approval that defines how the ties and fastener components will be stacked and the area required.

B. Ties shall be lifted and supported during manufacture, storage, transportation, loading, unloading, and stockpiling in a way which will prevent chipping, spalling, cracking, or other damage.

C. When ties are stacked in multiple tiers, each tier shall be separated with dunnage having sufficient thickness to clear fastening shoulder inserts.

D. Ties shall be uniformly vertically supported. All dunnage and separators shall be in or align with the rail seat area.

E. Tie sets required for special trackwork units shall be packaged separately and each shall be marked with the special trackwork unit identification number, unique color coding and location number. Complete tie sets shall be first sent to the manufacturing facility of the special trackwork, for required complete pre-assembly prior to shipment to the District.

PART 2 – PRODUCTS

2.01 DISTRICT-FURNISHED MATERIALS

A. Refer to Section 01 64 13, District-Furnished Materials and Equipment, of the Contract Specifications for description and quantity of District-furnished materials.

2.02 CONTRACTOR-FURNISHED MATERIALS

A. All products, tools, materials, equipment and labor required to complete all aspects of the work shall be furnished by the Contractor.

2.03 CT AND SPCT MATERIALS

A. CTs and SPCTs shall be pre-stressed monoblock design fabricated by the long-line method in accordance with domestic industry practice, as shown in the contract drawings.

B. SPCTs shall also include insulated rail fastenings consisting of embedded cast iron shoulders, drive on spring clips, plastic insulators and pads. Threaded fastener inserts shall be provided for attachment of the switch machine and contact rail or contact rail brackets.

1. Gage plates shall not be used.

2. Location and tolerances of turnout plates and inserts shall be in accordance with the manufacturer’s drawings and specifications and shall yield the tolerances provided herein.

3. Third rail insulators support shall either be directly supported or use standard third rail insulator brackets and shall be provided on both ends of all special trackwork ties, except between the running rail and switch machine.

4. Threaded fastener inserts for switch machines shall be the same type required for use for anchor bolts on direct fixation fasteners.

5. Special trackwork tie lengths shall be even foot lengths between ten feet and 22 feet, except ties using the flexible fastener assembly which shall be even foot or half foot lengths. Where ties longer than the maximum length are required, special design ties using a flexible fastener assembly shall be provided:

    a. Each tie segment shall support at least two running rails.

    b. The flexible fastener assembly shall not be located between adjacent stock rails through switches.

    c. The flexible fastener assembly shall not be located between a switch machine and the switch it actuates.

d. Special trackwork ties longer than the maximum provided for herein will only be considered by the Engineer as an exception when the requirements for flexible fastener requirements herein cannot be met.

e. The distance from the base of the rail to the end of a tie shall be between 17 and 40 inches.

f. Where tracks converge or where multi-piece ties are required within special trackwork, the minimum space between tie ends shall be three inches.

g. Special trackwork ties of the same length shall be identical.

6. Contact Rail Support Inserts:

a. Thread shall be 5/8 inch, 11 UNC, class 2B, minimum engagement length of one inch.

b. Stainless steel meeting requirements of ASTM, Type 304.

c. Plastic internal cap plugs shall be furnished and installed in all inserts as soon as possible after manufacture to prevent entry of moisture and debris.

7. Ties shall be tested to confirm the key minimum strength requirements shown in Table 2.

Table 2 - Concrete Tie Key Minimum Strength Requirements

TEST	MINIMUM REQUIREMENT
Concrete Compression	7000 psi at 28 days
Railseat Positive Bending Moment	170 kip-inch
Tie Center Negative Bending Moment	170 kip-inch
Rail Fastener Repeated Load Test	3,000,000 cycles
Rail Fastener Longitudinal Restraint	2,400 to 3,000 pounds
Rail Lateral Rotation	1/4 inch at 10,000 pounds

C. Portland Cement: ASTM C150/C150M, Type II low alkali (having the lowest possible alkali content that can be routinely produced in the market where the ties will be manufactured, but not more than 0.60 percent alkali content per Table 2 Optional Chemical Requirements). Use only the brand of cement identified in the approved mix design. Conduct false set penetration tests per ASTM C359. False set penetration values shall not be less than 50 mm initially; 35 mm at intermediate times, and 40 mm after remix. Conduct tests at three, five, eight, and 11 minutes and after remix, at a frequency of not greater than three months, analyze a randomly chosen sample of cement for alkali content in accordance with ASTM C114. Monitor uniformity of cement using methods described in ASTM C917. Cement shall be sampled at the rate of one sample per 1,000 tons received at the precast plant.

D. Concrete Aggregates: Fine and coarse aggregates shall be hard, strong, and durable crushed stone or gravel, clean and free of deleterious materials.

1. Coarse Aggregate: ASTM C33/C33M, clean and uniformly graded from No. 4 to 3/4-inch maximum size (ASTM C33/C33M, Size No. 67).

2. Fine Aggregate: ASTM C33/C33M, uniformly graded from 1/4-inch to fines, washed clean.

3. Reactivity: Submit evidence which indicates that the aggregates proposed for use meet, and will continue to meet, the requirements of ASTM C33/C33M for gradation, deleterious substances, and soundness. Attention shall be given to the requirements of sections 6.3 and 10.3 of ASTM C33/C33M. The environment shall be regarded as wet, moist, or humid. Notwithstanding the statement that reactive aggregates may be used provided that cement containing less than 0.6 percent equivalent alkalis is used, or the addition of a material shown to prevent harmful expansion, concrete mixes proposed for use in the ties shall be shown to be free from excessive expansion, and shall continue to be free from excessive expansion. This evidence shall include at least the following test results.

a. ASTM C33/C33M, Appendix XI for all types of aggregates, shall be submitted with the mix design.

b. ASTM C1260: Perform test using the cement and additives identified in the mix design. If expansions greater than 0.10 percent are developed within 16 days from casting, additional mortar bars from fine and coarse aggregates shall be tested per ASTM C227. Aggregates tested per ASTM C227 are considered potentially capable of harmful alkali reactivity if bars show at an age of three months storage an expansion greater than 0.05 percent. Submit test results with design mix and every six months during production to confirm that the aggregates are innocuous.

c. ASTM C586 and ASTM C1105 for aggregates from calcitic dolomites or dolomitic limestones as an alternative to b. above.

d. Conduct Duggan Concrete Expansion Test in accordance with AREMA prior to manufacture and every six months thereafter during manufacture.

E. Water

1. Water for mixing concrete shall be potable and free from harmful amounts of oils, acids, alkalis, salts, organic materials, or other substances which may be deleterious to concrete or steel. The water-soluble content of the concrete at the time of cross-tie production shall not exceed 0.06 percent by weight of portland cement. During the trial mixes, the water-soluble chloride content of ingredients proposed for use in ties shall be determined separately, and the combined total water-soluble chloride content shall not exceed 0.06 percent by weight of portland cement. Water-soluble chloride content of the concrete at the time of cross tie production shall be determined and at a frequency of not greater than three months. If at any time the water-soluble chloride content of the concrete approaches the 0.06 percent limit, the water-soluble chloride

content of the individual ingredients used to make the concrete shall be checked as often as necessary until the source of the higher water-soluble chloride content has been identified and corrective action to lower the chloride content has been accomplished. Perform necessary tests including those in accordance with the following test methods:

a. Admixtures: ASTM C494/C494M

b. Water and Ice: ASTM D512

c. Aggregate: ASTM D1411

2. Submit test results with design mix and every three months during production to confirm the acceptable level of total water-soluble chloride.

F. Concrete Admixtures

1. Acceptable concrete admixtures may be included in the concrete mix to improve the water-cement ratio or workability of the concrete, providing the strengths specified and other desirable characteristics of the concrete can be achieved and maintained. Obtain Engineer's written acceptance of admixtures prior to their use.

2. Water-reducing admixtures, retarding admixtures, accelerating admixtures, water-reducing and retarding admixtures, water-reducing and accelerating admixtures, and high range water reducing admixtures, if used, shall conform to ASTM C494/C494M or ASTM C1017/C1017M in the case of superplasticizers. Admixtures containing chlorides will not be permitted.

3. Silica Fume

a. For the purpose of increasing the electrical resistivity of the concrete in order to reduce the effect of stray currents, the concrete mix design shall incorporate the use of silica fume, unless alternative mix(es) demonstrate compliance with Article 2.03.F.3.b. The dosage rate shall be five percent by weight of the portland cement used in the mix. The maximum specified water cement ratio of 0.4 shall be calculated on the basis of the combined weight of portland cement and silica fume. Test proposed concrete mix in accordance with AASHTO T277 to determine the coulomb rating that is achieved at 56 days by discreet testing and not by interpolation of test data. Submit data from the following tests: Two sets of specimens shall be prepared and tested using the AASHTO T277 procedure. The first set of specimens shall be moist cured for a period of 28 days, then placed in an air drying facility maintained at 73 plus or minus three degrees Fahrenheit and 50 plus or minus five percent relative humidity until an age of 56 days, then tested. The second set of specimens shall be cured in a manner identical to that applied to the actual ties (i.e. low pressure steam, radiant heat), then placed in the air-drying environment noted above until an age of 56 days, then tested. All specimens shall be produced as 4 x 8-inch cylinders. At the test age of 56 days, a two-inch thick slice shall be obtained from the central portion of each cylinder and used for the test specimen. No fewer than three test specimens shall be prepared and

tested for each mix to be evaluated. Submit the test results with the design mix.

b. The bond between the concrete and the tendons may be adversely affected by the expected need for superplasticizer with the silica fume. The final acceptance of the mix design will be based on the results of the qualification testing and the quality control testing specified herein.

G. Prestressing Steel Tendons

1. Strands for prestressing tendons shall conform to ASTM A416/A416M or ASTM A886/A886M. Wires for pretensioning tendons shall conform to ASTM A881/A881M.

2. Strands other than those listed in ASTM A416/A416M or ASTM A886/A886M and wires other than those listed in ASTM A881/A881M may be used provided they conform to the requirements of these specifications and have no properties that make them less satisfactory than those listed in these specifications.

3. Minimum prestress working force after long-term losses shall be 75,000 pounds.

2.04 GENERAL PRODUCTION

A. Production of concrete ties or components prior to the Engineer's review and approval is prohibited.

B. Manufacture all concrete ties using the same methods used to produce qualification test pieces.

2.05 PRODUCTION OF CONCRETE CROSS AND SPECIAL TRACKWORK TIES

A. Concrete Quality

1. Water content shall be kept to a minimum consistent with the strength requirements and placement needs. Concrete mixes shall be proportioned to produce a compressive strength of at least 7000 psi when tested at 28 days in accordance with ASTM C39/C39M.

2. The 28 day flexural strength shall be at least 700 psi.

3. Concrete strength at stress transfer shall be adequate for the requirements of anchorages and for the transfer of stress through bond. Strength at the time prestress is transferred to the concrete shall be not less than 4000 psi. Calculated concrete stresses shall be in accordance with ACI 318, in Chapter entitled "Serviceability Requirements under Permissible Stresses in Concrete-Flexural Members".

B. Concrete Mix Proportions

1. Concrete mix design shall be qualified based on previous data which shows that a concrete mix will be satisfactory for the production of concrete ties, or new concrete mix designs established by tests on trial batches to achieve the required specified strengths and properties. The mix design submittal shall include at least the following data to demonstrate conformance with the requirements.

    a. Qualifications testing of all concrete components including admixtures.

    b. Proportions of all concrete components.

    c. Concrete strength, shrinkage, and permeability test results.

2. A new design mix shall be submitted to qualify the mix if any constituents of the concrete are changed during production of the ties.

3. The cement content shall not be less than 660 pounds per cubic yard.

4. Water-cement ratio shall not exceed 0.40 by weight and shall be calculated on the basis of the combined weight of cement and silica fume.

5. Trial mixes using aggregate, water, cement, and admixtures proposed for the manufacturer of concrete ties shall be made using at least three different water-cement ratios which will produce a range of strengths encompassing those specified herein. For each water-cement ratio, at least three specimens for each age to be tested shall be made, cured, and tested as hereinafter specified.

    a. Compressive strength tests shall be performed at 28 days and at the age at which transfer will be made as specified herein. A curve shall be established showing the relationship between water-cement ratio and compressive strength. The maximum permissible water-cement ratio for the concrete to be used shall be that shown by the curve to produce average strengths of 110 percent of those specified herein, provided the water-cement ratio shall be no greater than 0.40 when measured by weight.

    b. Flexural strength tests shall be performed at 28 days as specified herein, for each trial mix.

    c. The concrete mix proposed for use shall be tested for drying shrinkage in accordance with ASTM C157/C157M and ASTM C490/C490M using three specimens 4 inches by 4 inches by 11 inches. Shrinkage shall not exceed 0.003 inch per inch after storage in lime-saturated water for 28 days and air storage for 28 days.

6. The proportions of aggregate to cement shall produce a mixture that will work readily into corners and angles of the forms and around the prestressing tendons with the assistance of specified vibration, but without permitting the materials to segregate or excess free water to collect on the surface.

C. Compressive strength tests of concrete shall be performed to check the adequacy of mix proportions and as a basis for acceptance.

1. Samples for compressive-strength test specimens shall be obtained in accordance with ASTM C172/C172M. Specimens shall be made and laboratory cured in accordance with ASTM C31/C31M. Specimens made to check the adequacy of curing and protection of concrete shall be cured under production conditions. Concrete temperature shall be recorded during curing.

2. Compressive strength tests shall be performed on standard cylinders, 6 inch by 12 inch or 4 inch by 8 inch in size, in accordance with ASTM C39/C39M. For each day of production at least six cylinders shall be prepared and capped per ASTM C617/C617M for each production line: two for 28-day strength tests, two for checking strength at prestress transfer, and two for spares.

D. Flexural strength tests shall be performed to check the adequacy of the mix proportions design. Samples from which flexural test specimens are molded shall be obtained in accordance with ASTM C31/C31M. Three test specimens shall be prepared and tested for each test age.

1. Flexural strength tests shall be performed on 6 inch by 6 inch by 30 inch beams in accordance with ASTM C78/C78M. For each week of production, three beams shall be prepared from each production line. Beams shall be tested at 28 days age.

E. Ties shall be manufactured by the long line process. Conform with applicable requirements of the AREMA Manual and PCI MNL 116.

F. Forms

1. Forms shall be rigid and shall be constructed of material that will result in finished ties conforming to the shape, lines, and dimensions indicated. Tolerances in excess of those indicated or specified will not be permitted.

2. Forms for ties shall be constructed to permit movement of the tie without damage during transfer of the prestressing force.

3. Forms shall provide proper marking with indented or raised letters or numerals to identify the manufacturer and year of production. Marking for year of production and form cavity number shall be placed on tie top surface at the end opposite the contact rail support.

4. Forms shall be modified to fabricate ties with conduits.

G. Pre-stressing tendons in ties shall be accurately placed and adequately secured in position. Prior to placing concrete, the dimensional accuracy of the position of pre-stressing tendons, bulkheads, inserts, conduits, and anchorage devices shall be verified. Pre-stressing tendons shall be inspected for proper surface condition. Tendons contaminated with form release agents and other substances that will reduce bond with concrete shall be cleaned.

H. Application and Measurement of Pre-stressing Force

1. Initial pre-stressing force in each of the tendons shall not exceed 75 percent of the ultimate strength for stress-relieved strand and stress relieved wire and 70 percent of ultimate strength for direct drawn wire.

2. The force shall be applied in two increments. An initial force shall be applied to the tendons to straighten them, eliminate slack, and provide a starting or reference point for measuring elongation.

3. Pre-stressing force shall be determined by reading hydraulic ram pressure on a calibrated gauge or by the use of a calibrated dynamometer. Elongation measurements shall be taken from average load-elongation curves for the steel used. Actual elongation shall agree with the elongation calculated, using the force determined from the pressure gauge within plus or minus five percent. The cause of any discrepancy that exceeds plus or minus five percent shall be ascertained and corrected before production may continue.

4. Tendons may be stretched either individually or simultaneously. If tendons are stretched simultaneously, provision shall be made to induce approximately equal stress in each.

5. Transfer of force from the abutments of the pre-tensioning bed to the concrete shall be carefully accomplished by gradual and simultaneous detensioning of all tendons. Exposed tendons shall be cut near the tie end. The projection of tendons beyond the ends of the ties shall not exceed 1/4 inch.

I. Mixing, Placing, and Curing of Concrete

1. Prior to placing concrete, equipment for mixing the concrete shall be clean, debris shall be removed from spaces to be occupied by the concrete, forms shall be oiled, and the tendons shall be cleaned of deleterious coatings. Forms shall be inspected for alignment and tightness of joints, and the dimensional accuracy of the position of bulkheads, prestressing tendons, inserts, and other embedments shall be verified.

2. Proportioning of Concrete Materials

   a. Fine and coarse aggregates and cement shall be measured by weight. Weights of aggregates shall be based on a saturated surface dry condition corrected for free moisture.

   b. Water and liquid admixtures may be measured by weight or volume.

   c. The accuracy of measurement of the concrete ingredients shall be within the following percentage limits shown in Table 3.

Table 3 – Concrete Ingredient Accuracy	
Ingredients	**Percent Accuracy**
Cement	1
Water	1
Fine aggregate	2
Coarse aggregate	2
Cumulative aggregate	2
Admixtures	3

3. Mixing of Concrete

    a. Mixing equipment shall be capable of combining specified materials within the time specified by the equipment manufacturer into a thoroughly mixed and homogeneous mass, and discharging the mixture without segregation.

    b. Concrete shall be mixed until there is a uniform distribution of the materials, and shall be discharged completely before the mixer is recharged.

    c. Optimum mixing time shall be established by the equipment manufacturer's specifications. Generally, minimum mixing time shall be one minute for batches of 1 cubic yard or less. This mixing time shall be increased by at least 15 seconds for each cubic yard, or fraction thereof, of capacity in excess of one cubic yard. Mixing time shall be established for the silica fume concrete mix in order to produce batch-to-batch uniformity. Batch-to-batch uniformity shall be evaluated using the procedures described in Annex A.1, Concrete Uniformity Requirements, ASTM C94/C94M. Both under mixing and over mixing shall be avoided.

4. Conveying

    a. Concrete shall be conveyed from the mixer to the place of final deposit in the shortest practicable time by methods that will prevent segregation or loss of materials.

    b. Equipment for chuting, pumping, and pneumatic conveying of concrete shall be of size and design to assure flow of concrete at the delivery end without segregation of materials.

5. Depositing

    a. Concrete shall be deposited as nearly as practical in its final position to avoid segregation due to re-handling or flowing. Concrete that has partially hardened or has been contaminated by foreign materials shall not be used.

b. Concrete shall not be placed when the ambient air temperature is below 40 degrees Fahrenheit. Concrete shall have a minimum temperature of 50 degrees Fahrenheit, and a maximum temperature of 90 degrees Fahrenheit. When concrete is placed at an ambient temperature of 90 degrees Fahrenheit or greater, special precautions to prevent rapid drying shall be employed. Comply with applicable requirements of ACI 305R.

6. Consolidating

a. Concrete shall be thoroughly consolidated by vibration during placement, and shall be thoroughly worked around the pre-stressing tendons, embedded inserts, and into the corners of the forms.

b. External form vibration or internal concrete vibration or a combination of both shall be used to obtain uniform mix, and shall be sufficient to yield concrete with a density of not less than 145 pounds per cubic foot.

c. Forms shall not be damaged during consolidation.

7. Curing

a. Ties shall be cured by steam, radiant heat, or other accepted curing process to accelerate strength gain so that removal of forms and transfer of the pre-stressing force may be accomplished at an early age.

b. Curing shall be performed in accordance with procedures established by the Pre-cast/Pre-stressed Concrete Institute to produce the concrete strengths specified. The pre-steam period shall be three to four hours. Temperature gradient shall not exceed 30 degrees Fahrenheit per hour. Maximum curing temperature shall not exceed 140 degrees Fahrenheit, unless the supplier can demonstrate that the materials used would be satisfactory for long term durability, in which case temperatures up to 158 degrees Fahrenheit may be used. Referenced temperatures are concrete, not ambient.

8. Ties shall be removed from forms in a manner that will prevent damage to the forms or ties.

9. Finishing

a. Formed surfaces of the finished ties shall have a smooth and dense uniform surface. Surface of the rail seat shall have a smooth finish and shall be free from surface irregularities and excessive air holes. Other surfaces shall have a smooth finish that may contain honeycomb not to exceed two percent of the surface and a maximum void diameter and depth of 3/8 inch.

b. Bottom surface of the ties shall have a rough or coarse finish as may be obtained with a medium coarse broom or wood float.

c. Two ties, which in the opinion of the Engineer, show the required finishes shall be set aside as comparison standards for acceptance of the ties.

J. Acceptance Tests for CT and SPCT

1. Approval of the tie design is dependent upon the successful completion of the testing program needed. Retesting and redesign, if required, shall be at the fabricator's expense.

2. From a lot of not less than five ties produced in accordance with these Specifications, three ties will be selected at random by the Engineer for laboratory testing.

3. If required for design testing of the fastening system, the fabricator shall also furnish a section of a tie or a concrete block with rail seat and fastening system identical to the ties furnished for testing. The age of test ties or concrete block at time of testing shall be at least seven days but not more than 28 days.

4. Each of the three ties, and if required the tie block, submitted for testing shall be carefully measured and examined to determine their compliance with the specified dimensions and tolerances. Upon satisfactory completion of the examination, two ties, designated as Tie No. 1 and Tie No. 2, shall be subjected to performance tests as specified herein. The remaining tie, which will be designated as Tie No. 3, will be retained by the fabricator for further test use and as a control for dimensional tolerances and surface appearance of ties subsequently produced.

K. Dimensions and Tolerances shall conform to that provided in Table 4.

Table 4 – Concrete Tie Dimensional Tolerance

Dimension	**Tolerance**
Nominal Length	±1/4”
Width of Bottom	±1/4”
Width of Top at Center of Rail seat	±1/8”
Maximum Top Corner Chamfer	1 inch by 45 degrees.
Depth at Center of Rail Seat	±1/16”
Depth at Center of Tie	±1/16”
Distance between the inside faces of the field embedded shoulder inserts	+0”, -1/8”
Standard Concrete Tie Centerline	±1/8” of Track Gage Centerline
Standard Concrete Tie Rail Seat Cant	1 in 40 +/- 5
Concrete Special Trackwork Tie Rail Seat Cant	0 +1 degree, -0 degree
Rail Seat Differential Tilt	±1/16 inch in a width of 6 inches
Rail Seat Plane	±1/32”
Protrusion of Pretensioning Tendons	+1/4”, -0”

L. Sequence of design performance tests using Tie no. 1 shall be as follows:

1. Rail seat Positive Bending Moment Test shall be performed on the two rail seats designated “A” and “B”.

2. Center Negative Bending Moment Test.

3. Bond Development and Ultimate Load-Test shall be performed on Rail seat A.

M. Sequence of design performance tests using Tie No. 2 shall be as follows.

1. Rail Fastening Shoulder Test shall be performed on all shoulders.

2. Contact Rail Insert Test shall be performed on all inserts.

3. Rail Fastening Uplift Test shall be performed on one rail seat.

4. Electrical Resistance and Impedance Test.

N. Rail Seat Positive Bending Moment Test: With the tie supported and loaded as indicated in Figure 1, a load P shall be applied in such a manner as to avoid shock until a load of 17,500 pounds is obtained. This load shall be held for not less than three minutes, during which time an inspection shall be made to determine if structural cracking occurs. Structural cracking is defined in the AREMA Manual. A five-power magnifying glass shall be used to locate cracks. If structural cracking does not occur, the requirements of this test will have been met.

O. Center Negative Bending Moment Test: With the tie supported and loaded as indicated in Figure 2, a load P shall be applied at a uniform rate and in such a manner as to avoid shock until a load of 7,500 pounds is obtained. This load shall be held for not less than three minutes, during which time an inspection shall be made to determine if structural cracking occurs. Structural cracking is defined in the AREMA Manual. A five-power magnifying glass shall be used to locate cracks. If structural cracking does not occur, the requirements of this test will have been met.

P. Bond Development and Ultimate Load Test: With the tie supported and loaded as indicated in Figure 1, a load P shall be applied as specified herein, and increased until a load of 26,250 pounds is obtained. The load shall be held for not less than three minutes. If there is no more than 0.001 inch strand slippage determined by an extensometer reading to 0.0001 inch, the requirements of this test will have been met. The measurements shall be made on the outermost tendons of the lower layer. The load P shall be increased until ultimate failure occurs. The ultimate failure so obtained shall exceed 29,750 pounds.

Q. Daily Production Quality Control Tests. In addition to the production quality control tests outlined above, the following tests shall be performed:

1. The distance between the inside faces of the field embedded shoulder inserts, the height of all embedded shoulder inserts and contact rail insert location shall be verified on every tie, and, by use of a templates.

2. One tie selected at random from each lot of 200 ties or fraction thereof produced each day shall be subjected to the following tests:

3. The rail seat Positive Bending Moment Test as specified in herein, shall be performed on both rail seats. Ties that pass testing requirements and are not structurally cracked or otherwise damaged will be accepted. All other ties shall be rejected.

4. All ties in the lot will be accepted if the test tie passes the above tests. If the test tie fails either of the tests, two additional ties from the same lot shall be subjected to the same test, and acceptance of the lot shall be based on the following conditions.

    a. If both retest ties meet the test requirement, the lot will be accepted.

    b. If either of the retest ties fails to meet the test requirements, two additional ties from each line shall be selected. (A line is defined as one form cavity wide by the number of forms, end-to-end.) The two additional ties shall be subjected to the tests, and if both ties meet the test requirements, that line of ties will be accepted. If either of the ties fails to meet the test requirements, the entire line shall be rejected or each individual tie in the line shall be tested in order to determine if the test requirements have been met. Ties meeting the requirements will be accepted.

R. In addition to the production quality control tests outlined above, the following tests shall be performed.

1. One tie selected at random from every 1,000 ties produced and accepted on the basis of meeting the requirements herein, shall be tested for bond development and ultimate strength as specified herein.

2. If either of the retest ties fails to meet the test requirements, three additional ties from each line shall be selected. The three additional ties shall be subjected to the tests, and if the three ties meet the test requirements, that line of ties will be accepted. If any of the ties fails to meet the test requirements, the entire line shall be rejected or each individual tie in the line shall tested in order to determine if the test requirements have been met. Ties meeting the requirements will be accepted.

S. Design qualification testing of the fastening system consists of testing components cast into the ties in addition to tests conducted on the external components as specified below. The rail fastening system shall conform to the testing requirements, herein, in all positions of lateral adjustment.

T. Sequence of design tests shall be as follows.

1. Rail Fastening Repeated Load Test.

2. Rail Fastening Longitudinal Restraint Test.

3. Rail Fastening Lateral Restraint Test.

U. Rail Fastening Shoulder Test.

1. The following test shall be performed on each shoulder as indicated in Figure 3 to determine the ability of shoulders to resist tension. An axial load P of 8,000 pounds shall be applied to each shoulder separately and shall be held for not less than three minutes. The embedded shoulder shall not move and the concrete shall not crack, as observed by visual inspection. Separation of laitance surrounding the shoulder will not be cause for rejection.

2. Following successful completion of the shoulder pull-out test, the torque test shall be performed on each shoulder. A torque of 250 foot-pounds shall be applied about the vertical axis of the shoulder by means of a calibrated torque wrench and a suitable attachment to the shoulder. The torque shall be held for not less than three minutes. Ability of the shoulder to resist this torque without rotation, cracking of concrete, or permanent deformation shall constitute passage of this test.

V. Contact Rail Insert Test: The following test shall be performed on each contact rail insert in a manner similar to Figure 3 to determine the ability of inserts to resist tension when the surrounding concrete is unrestrained. An axial load P of 3500 pounds shall be applied to each insert separately and shall be held for not less than three minutes. The embedded insert shall not move and the concrete shall not crack, as observed by visual inspection. Separation of laitance surrounding the insert will not be cause for rejection.

W. Rail Fastening Uplift Test: An 18 inch to 20 inch section of 119 RE rail shall be secured to one rail seat using a complete rail fastening system including pads, clips, and associated hardware, as recommended by the manufacturer of the rail fastening system. In accordance with the loading diagram in Figure 4, an incremental load shall be applied to the rail. The load “P” at which separation of the rail from pad or pad from rail seat occurs (whichever occurs first) shall be recorded. The load shall then be completely released. A load of 1.5P shall then be applied. The shoulders shall not pull out or loosen in the concrete, and no component of the fastening system shall fracture nor shall the rail be released.

X. Rail Fastening Repeated Load Test

1. An 18 inch to 20 inch section of 119 RE rail, from which loose mill scale has been removed by wiping with a cloth, shall be secured to the rail seat using a complete rail fastening assembly. In accordance with the loading diagram in Figure 4, determine the load “P” that will cause separation of the rail from the rail seat pad or the pad from the rail seat, whichever occurs first. This load may be determined during the Fastening Uplift Test specified herein, in which case a new set of fastening clips shall be used for the repeated load test.

2. An 18 inch to 20 inch section of 119 RE rail, from which loose mill scale has been removed by wiping with a cloth, shall be secured to the rail seat using a complete rail fastening assembly. In accordance with the loading diagram in Figure 5, alternating downward and upward loads shall be applied at an angle of 20 degrees to the vertical axis of the rail at a rate not to exceed 300 cycles per minute for three million cycles. The rail shall be free to rotate under the

applied loads. One cycle shall consist of both a downward and upward load. The magnitude of the upward load shall be 0.6P. If springs are used to generate the upward load, the downward load shall be 17,000 pounds plus 0.6P. If a double-acting hydraulic ram is used to generate both the upward and the downward load, the downward load shall be 17,000 pounds.

3. The repeated load test may generate heat in elastomeric rail seat pads. Heat build-up in such pads shall not be permitted to exceed 120 degrees Fahrenheit. Heat build-up may be controlled by reducing the rate of load application or by providing periods of rest to allow cooling of the pad.

4. Rupture failure of any component of the fastening system shall constitute failure of the test.

Y. Rail Fastening Longitudinal Restraint Test: After successful completion of the Rail Fastening Repeated Load Test specified herein, and without disturbing the rail fastening assembly in any manner, the tie and fastening shall be subjected to a longitudinal restraint test in both directions. A longitudinal load shall be applied as indicated in Figure 6, in increments of 400 pounds with readings taken of longitudinal rail displacement after each increment. Readings of rail displacement shall be the average of the readings of two dial indicators reading 0.001 inch. One dial indicator shall be placed on each side of the rail with the dial indicator plungers parallel to the longitudinal axis of the rail. The load shall be increased incrementally until a load of 2400 pounds is reached. This specified load shall be held for not less than 15 minutes. The rail shall not move more than 1/8 inch during this period. The fastening shall be capable of meeting the requirements of this test in either direction of loading. The tie and fastenings will have successfully passed this test if the specified criteria are met.

Z. Rail Fastening Lateral Restraint Test

1. An 18 inch to 20 inch section of 119 RE rail shall be secured to the tie block in a manner appropriate to the fastening being used. The entire assembly shall be supported and loaded as indicated in Figure 7. The loading head shall be fixed against translation and rotation. The wood block shall be 10 inches by 10 inches by 3/4 inch thick, five-ply exterior grade plywood.

2. A preload of 10,000 pounds shall be applied to the rail to seat the rail in the fastening. Upon release of the preload, a zero reading shall be taken on the dial indicators that measure rail translation. Readings of rail displacement shall be the average of the readings of two dial indicators reading 0.001 inch. Load shall be applied at a rate not to exceed 5,000 pounds per minute until either 19,000 pounds have been applied or the rail base has translated 1/8 inch, whichever occurs first. Inability of the fastening to carry the 19,000 pounds load with 1/8 inch or less of rail translation shall constitute failure of this test. Failure of any component of the tie or fastening is cause for rejection.

3. With all load removed from the rail, a roller nest shall be placed between the fixed loading head and the wood block on the rail head. The roller nest shall not offer resistance to lateral movement of the rail head. After taking zero readings on the dial indicators that measure gauge widening and rail translation, a load

of 10,000 pounds shall be applied at a rate not to exceed 5,000 pounds per minute. Rail rotation, gauge widening less rail translation, greater than 1/4 inch shall constitute failure of this test.

AA. Electrical Resistance and Impedance Test

1. Concrete test tie shall be assembled with insulating components, rail clips, and section of 119 RE rail. The rail section lengths shall be greater than the width of the tie.

2. The complete assembly shall be immersed in tap water for a minimum of six hours.

3. Within 1 hour after removal from the water, an alternating current, 100 V, 60 Hz potential shall be applied across the two rails for a period of 15 minutes. The contact points shall be cleaned.

4. The current flow in amperes shall be read using an alternating current ammeter, and the impedance shall be determined by dividing the voltage by the current flow in amperes.

5. If the impedance exceeds 40 kΩ, the tie will have passed the test.

6. After the rail fastener assemblies meet the repeated load test specified herein, the rail fasteners in dry condition shall have not less than 10 MΩ insulation resistance between the rail and the anchor bolts or other steel in contact with the ties, when measured with a 500 V “Megger” Insulator Tester. Rail fastener shall provide a minimum fastener impedance of 10 kΩ to all frequencies from 20 Hz to 10 kHz with maximum of 50 V ac.

BB. Tie Pad Test

1. One rail seat or the rail seat of the tie block shall be assembled using a short section of 119 RE rail, clips, insulators, and the pad to be tested.

2. The rail shall be loaded downward in the vertical direction of its axis using a loading machine capable of applying a load over the range of 0 to 20,000 pounds.

3. Displacement devices shall be attached to the rail capable of measuring vertical displacements of 0.0001 inch. Devices shall be located at the four corners of the pad.

4. Load shall be increased, at a rate between 3,000 and 6,000 pounds per minute, from 0 to 20,000 pounds in 1,000 pound increments. Deflection at each increment shall be read on the four measuring devices, averaged and recorded. Sufficient time shall be allowed at each increment of loading for the deflection to stabilize.

5. Measure and record the time in seconds during both the loading and unloading cycle.

6. At the completion of the loading cycle, the load shall be decreased, at a rate between 3,000 and 6,000 pounds per minute, in 1,000-pound increments, recording and averaging deflection as before.

7. Plot load versus deflection for the loading and unloading cycles.

8. Draw a line between zero and the 16,000-pound point for the loading and unloading load-deflection curves.

9. Calculate the slope of each line.

10. The requirements of this test shall have been met if when

    a. The slope of each line is between 1 by 10^6 and 2 by 10^6 pounds per inch, and

    b. The pad returns to within 0.002 inch of its original position within 10 seconds after removal of the final increment of load.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install concrete ties in accordance with the respective manufacturer's recommended installation instructions and procedures and as provided, except as modified herein.

B. Install concrete ties in accordance with the requirements of Section 34 05 17, Common Work Results for Trackway.

ATTACHMENTS (FIGURES) FOLLOW

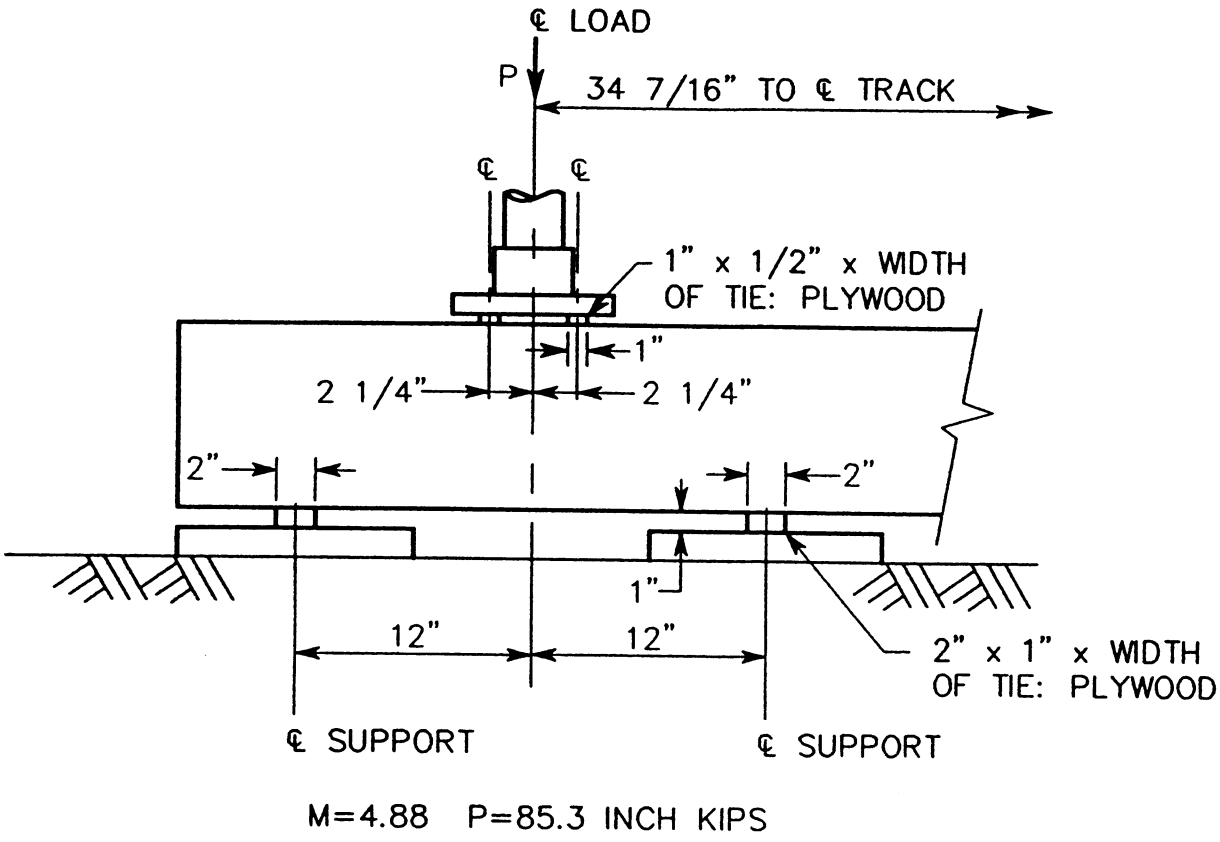


FIGURE 1 - TIE RAIL SEAT POSITIVE BENDING MOMENT TEST

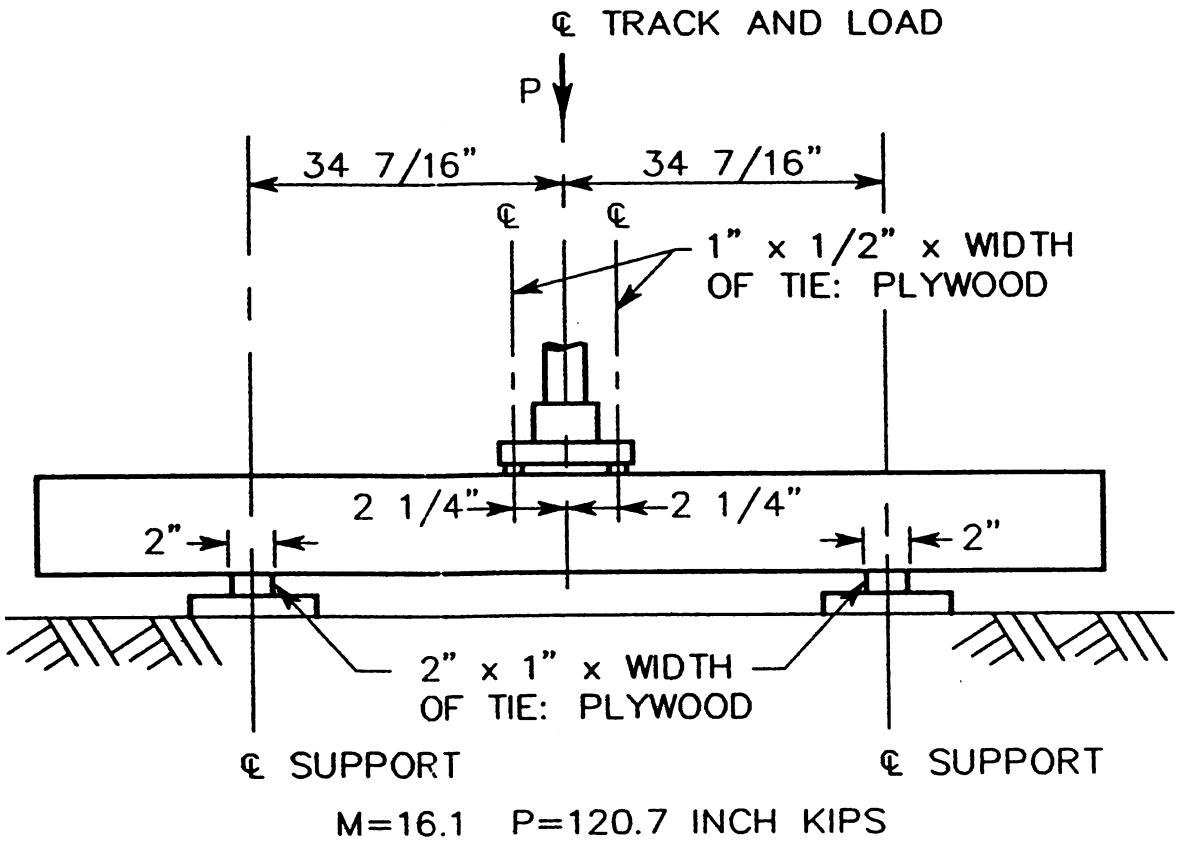


FIGURE 2 - TIE CENTER NEGATIVE BENDING MOMENT TEST

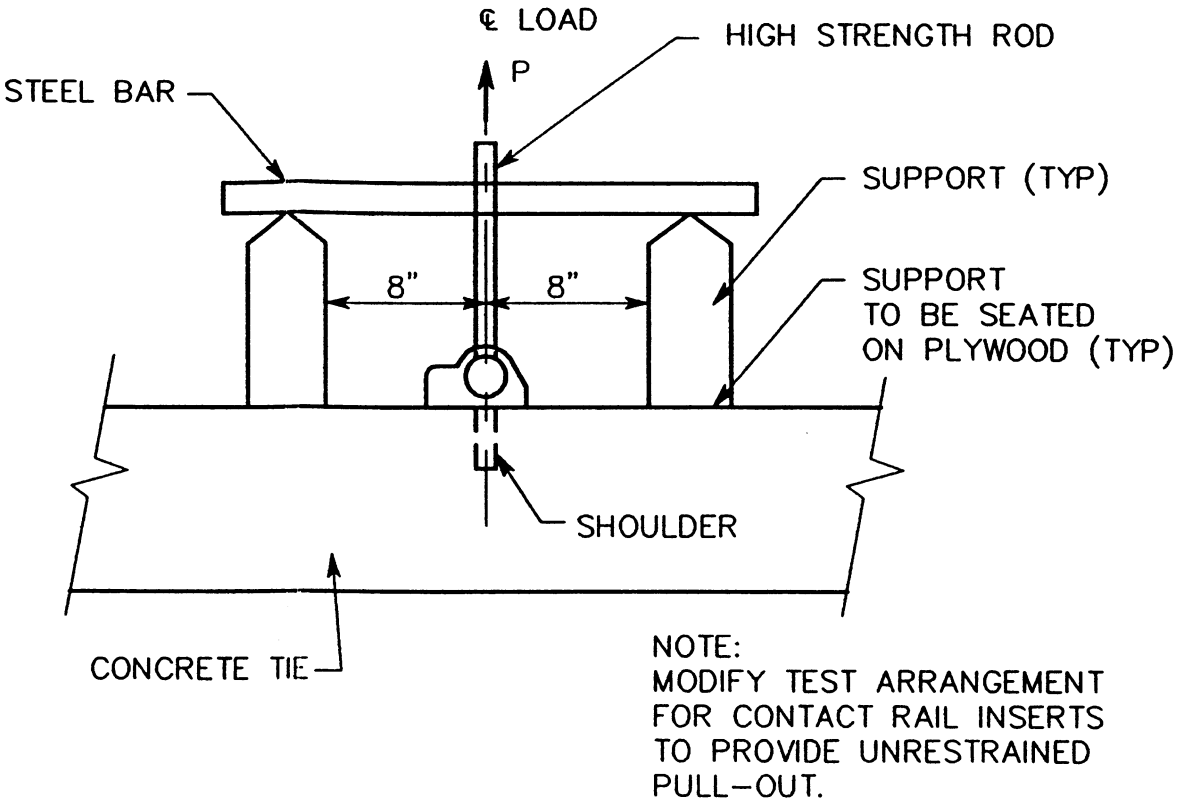


FIGURE 3 - TIE RAIL FASTENING SHOULDER AND CONTACT RAIL INSERT PULLOUT TEST

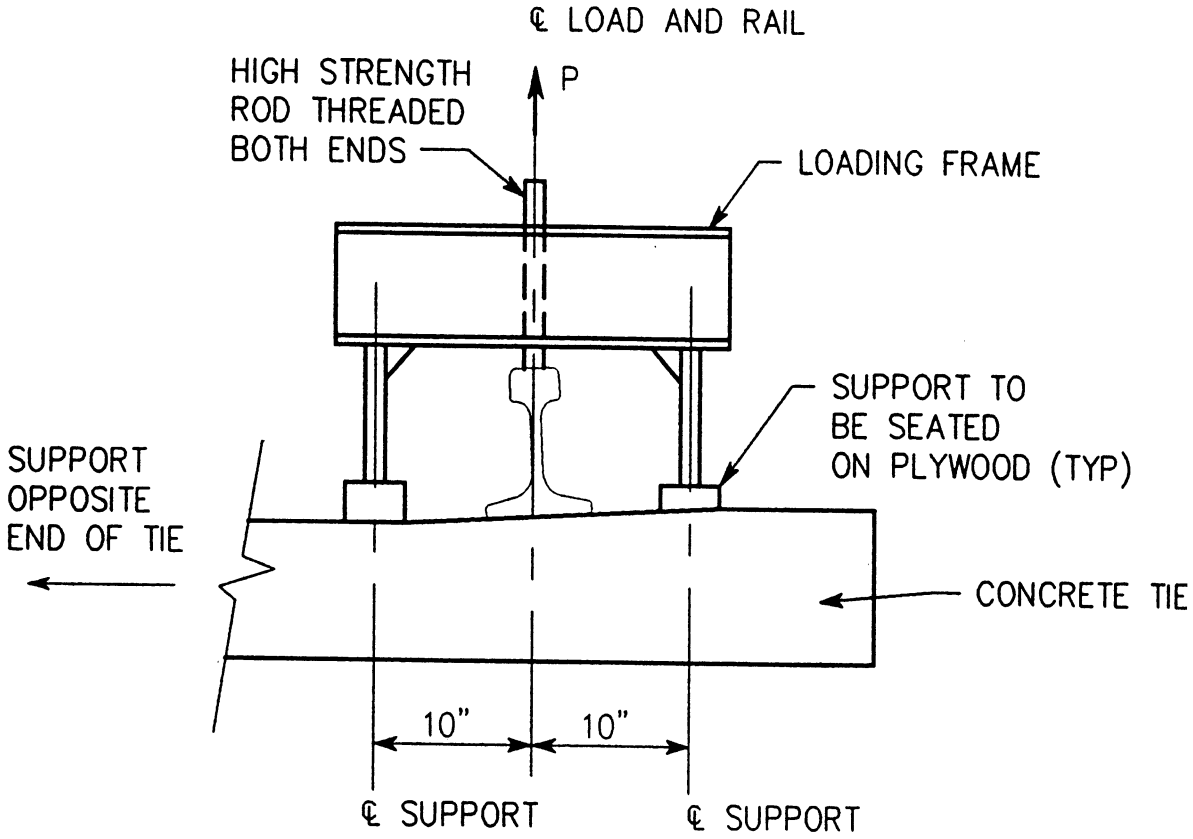


FIGURE 4 - TIE RAIL FASTENING UPLIFT TEST

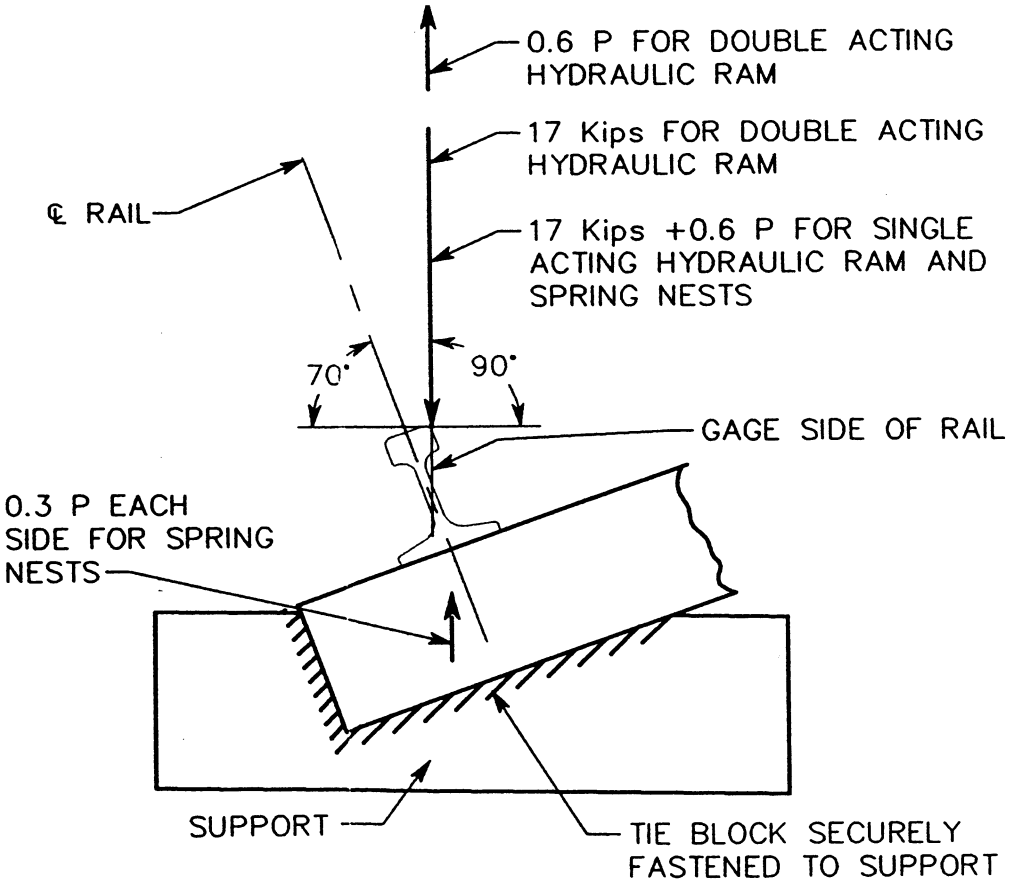


FIGURE 5 - TIE RAIL FASTENING REPEATED LOAD TEST

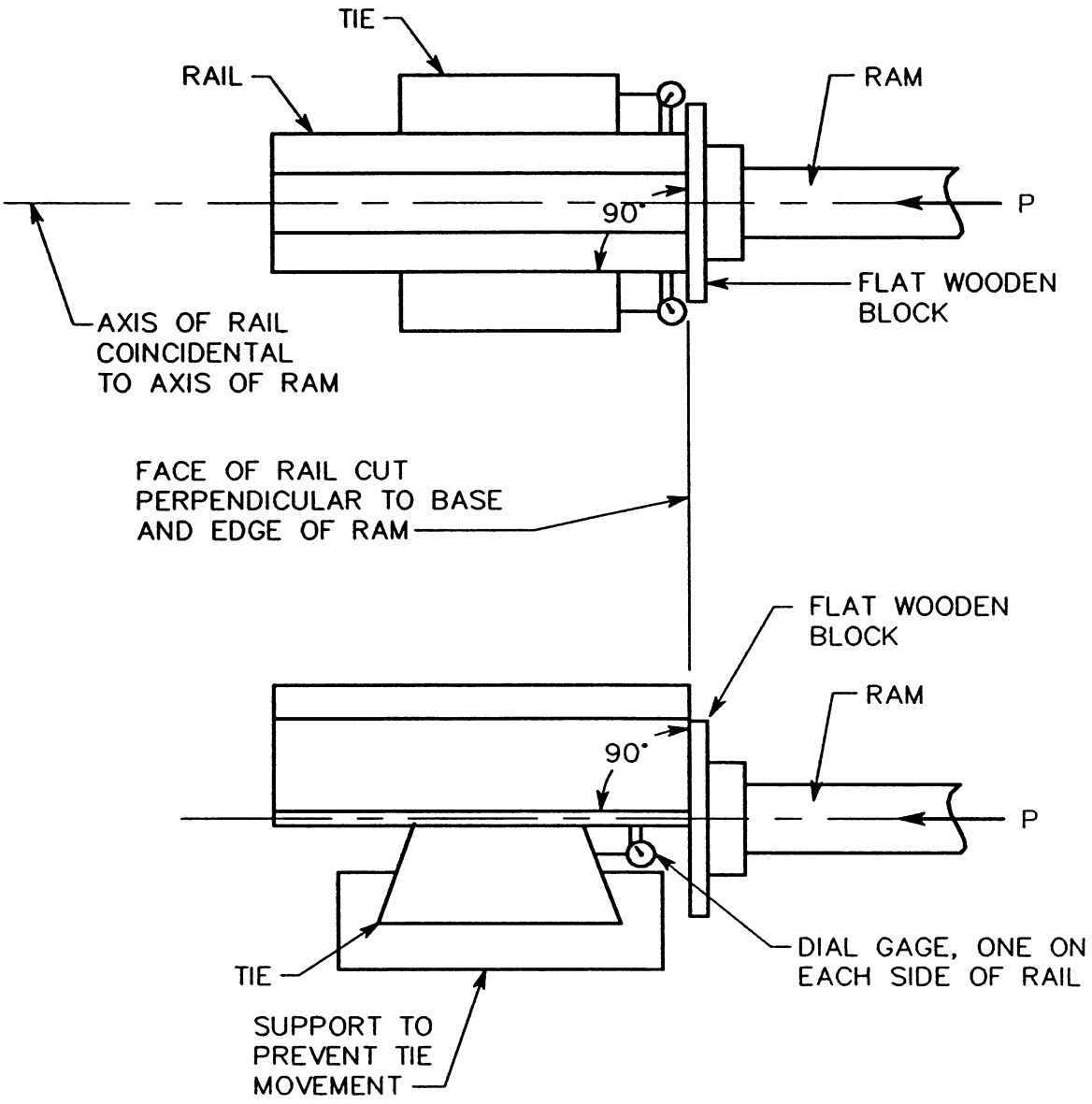


FIGURE 6 - TIE RAIL FASTENING LONGITUDINAL RESTRAINT TEST

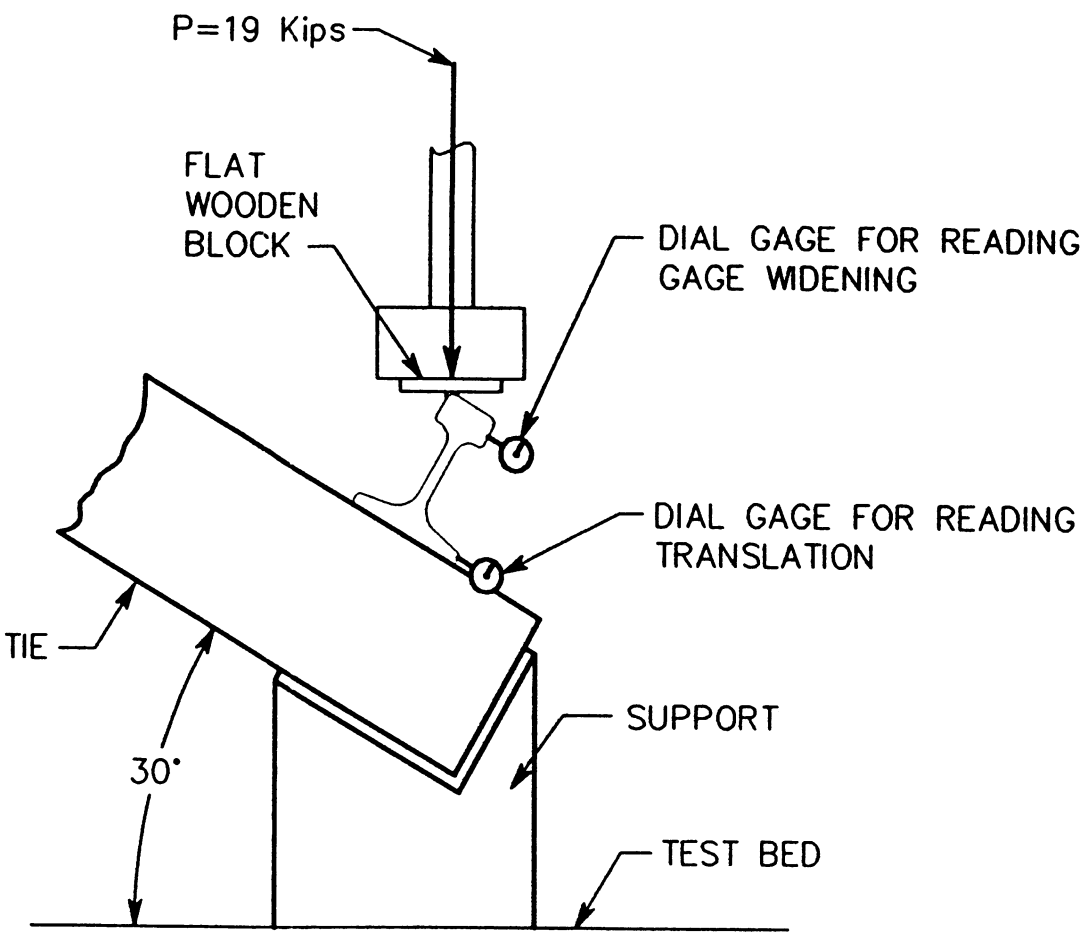


FIGURE 7 - TIE RAIL FASTENING LATERAL RESTRAINT TEST

END OF SECTION 34 11 31

SECTION 34 11 32

RESILIENT TIES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Standard Resilient Ties (RT).

B. Special Trackwork Resilient Ties (SPRT).

1.02 MEASUREMENT AND PAYMENT

A. Measurement and payment will be made for the item in the Bid Schedule of the Bid Form. All costs in connection with the work specified herein will be considered to be included.

1.03 REFERENCES

A. American Railway Engineering and Maintenance of Way Association (AREMA):

1. AREMA Manual
2. Manual for Railway Engineering

B. American Society for Testing and Materials (ASTM):

1.	ASTM C39/C39M	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
2.	ASTM C78/C78M	Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
3.	ASTM C192/C192M	Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
4.	ASTM D412	Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers-Tension
5.	ASTM D573	Standard Test Method for Rubber-Deterioration in an Air Oven
6.	ASTM D1149	Standard Test Methods for Rubber Deterioration-Cracking in an Ozone Controlled Environment
7.	ASTM D2240	Standard Test Method for Rubber Property-Durometer Hardness
8.	ASTM A615/ A615M	Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement

C. Precast/Prestressed Concrete Institute (PCI):

1. PCI MNL 116 Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products

1.04 SUBMITTALS

A. Provide additional Submittals as required herein.

1.05 RT AND SPRT SUBMITTAL

A. A RT and SPRT shall consist of independent precast concrete blocks, suitably reinforced and incorporate two rail fastening shoulders and SPRT baseplate anchoring. The proposed RT and SPRT system shall permit individual lateral adjustment of each rail, along with the third rail, using replaceable shims.

B. Separate Submittals are required for RTs and SPRTs.

C. Submit detailed Shop Drawings indicating the following:

1. Dimensional details of RTs and SPRTs showing plan, elevation, and cross sections. Include concrete strength and material specifications.

2. Location and spacing of reinforcement.

3. Dimensions and tolerances and location of rail fastening components for rail and rail joints, and turnout plates.

4. Plans and samples to demonstrate conformance with the track tolerance requirements.

5. Submit three samples to the District’s Representative within 90 Days following award of the Contract, of complete all various rail fasteners, including embedded shoulders, spring clips, insulators, and tie pads for review by the District’s Representative.

6. Recommendation for handling, transporting, and stacking of ties.

7. Submit list of sources proposed by the Supplier to obtain materials requiring approval, certifications, or testing.

1.06 RT AND SPRT QUALITY ASSURANCE AND CONTROL

A. Submittals:

1. RT and SPRT assembly drawings.

2. Detailed Shop Drawings and Contract Specifications for all RT and SPRT components.

3. Material certificates demonstrating that the RT and SPRT block pads are made of natural rubber or an equivalent material approved by the District's Representative and permitting to fulfill all the requirements herein.

4. Evidence satisfactory to the District's Representative that the block pad design will guarantee that the performance of the proposed RT and SPRT system will not be negatively affected by the unavoidable ingress of water into the rubber boots during revenue service.

5. Material certificates demonstrating that the RT and SPRT rubber boots are made of SBR and that the SBR content is at least 50 percent.

6. Evidence satisfactory to the District's Representative that the internal rubber boot wall design will be such that a 0.02 inch gap between the rubber boot and the concrete block is maintained during construction, thereby allowing the concrete block to freely move downward as the block pad deflects under load during revenue service.

7. Evidence satisfactory to the District's Representative that the rubber boot wall design will be such that replacing the original rubber boots with maintenance rubber boots having thinner walls will permit a Resilient Tie block pair (both running rail) to achieve the specified one inch lateral adjustment of the RT and SPRT units without compromising the long term performance of the system.

8. Calculations of the concrete block strength, track modulus and maximum pressure per area exerted by the RT and SPRT units against the encasement concrete, both vertically and laterally, and a justification that the resulting values are compatible with the axle load, train speed and track curvature conditions prevailing on the project.

9. A description of how the proposed RT and SPRT system will be installed and permit to achieve the performance criteria and dimensional tolerances specified for the completed track in terms of track gauge, rail cant, horizontal and vertical track alignment, superelevation in curves and future vertical and lateral track adjustment.

10. Production testing plan in accordance with the requirements herein.

11. Quality assurance plan.

B. Qualification Testing

1. All design qualification testing on the cross tie and fastener assembly shall be performed by an approved independent laboratory that is staffed, equipped, and experienced to perform the specified tests.

2. All daily production quality control testing shall be performed in accordance with the approved Test Program Plan.

3. The Supplier shall supply a minimum of 16 independent RT and SPRT units to be tested. These RT and SPRT units shall be Manufactured in the same manner as the Supplier plans to use for production runs. From the lot of 16 RT and SPRT units so produced the District's Representative shall select five units at random to be subjected to qualification testing. If any RT and SPRT unit fails to meet any of the testing requirements assigned to it, another unit shall be selected from the lot by the District's Representative and the corresponding tests shall be repeated. A second failure shall require the production of a new lot of 16 RT and SPRT units and the performance of another complete series of qualification tests.

4. The RT and SPRT units selected for testing shall be permanently marked with identifying numbers in accordance with the following sequence: A1, B1, C1, D1 and E1 for first iteration of tests and A2, B2, C2, D2 and E2 for second iteration of tests.

5. The testing sequence shall be as presented in the qualification test matrix shown in 2.

6. A RT and SPRT unit, fully assembled but not embedded in concrete, shall be aged in an air oven for a period of 70 hours at a temperature of 212 degrees Fahrenheit (or for a period of 336 hours at 160 degrees Fahrenheit if it comprises one or more natural rubber components) in accordance with ASTM D573, Accelerated Aging of Vulcanized Rubber by the Oven Method. EVA rail pads shall be exempt from this test.

7. Before assembly, the metal parts and elastomers shall be hand cleaned and wiped dry. They shall be assembled as shown in the approved shop drawings and installation description. The test configuration shall simulate fully installed embedded RT and SPRT unit conditions, except where specifically stated, and shall consist of two RT and SPRT units on 30 inch centers with a piece of the same rail as specified for the project that is at least 42 inches long assembled to the RT and SPRT units. The minimum encasement concrete depth below the embedded RT and SPRT units shall be two inches. The perimeter of the encasement concrete shall be located at least 20 inches horizontally from the nearest point of an embedded RT and SPRT unit. Any forms shall be removed prior to testing. The embedment concrete shall attain its full compressive strength prior to initiation of testing. The embedment concrete shall have a compressive strength of no less than 4,000 psi in accordance with ASTM C39/C39M.

8. Figure 4 illustrates a typical test assembly.

9. Vertical Assembly Stiffness

    a. Prior to the test, a minimum of ten 24,000 pound vertical loading cycles shall be applied downward at the center of the rail head midway between the RT and SPRT units to ensure the proper seating of all components. The vertical position of the rail head after the seating procedure shall be used as reference for all measurements taken during the test. A vertical load increasing in increments of 2,000 pounds to a maximum of 24,000 pounds at a rate of no less than 100 pounds per minute and no more than 1,000 pounds per minute shall be applied downward at the center of the rail head midway

between RT and SPRT units. For each increment of load, the vertical deflection of the rail head at each RT and SPRT unit shall be measured to the nearest 0.001 inch and shall be recorded. The load shall be removed and the final position of the rail head shall be measured and recorded. The values for vertical loads versus deflection shall be plotted on a graph.

b. The average spring rate of the RT and SPRT units shall be between 85,000 pounds per inch and 175,000 pounds per inch for the deflections at single rail seat loads of 4,000 pounds and 12,000 pounds. One minute after the removal of the maximum load, the rail head shall return to within 0.05 inch of the reference position. The RT and SPRT components shall not exhibit evidence of failure such as slippage, yielding or fracture.

10. Lateral Load Test

a. Prior to the test, a minimum of ten 14,000 pounds vertical loading cycles shall be applied downward at the center of the rail head midway between the RT and SPRT units to ensure the proper seating of all components. The position of the rail head after the seating procedure shall be used as reference for all measurements taken during the test. A vertical load of 14,000 pounds shall then be applied downward at the center of the rail head midway between the RT and SPRT units. A lateral load, increasing in increments of 1,000 pounds to a maximum load of 6,000 pounds, at a rate of no less than 100 pounds per minute and no more than 1,000 pounds per minute, shall be applied horizontally to the rail head at a point 0.625 inches below the top of the rail midway between RT and SPRT units in a direction normal to the vertical load. The lateral displacement of the rail head shall be continuously measured throughout the loading sequence at a point 0.625 inches below the top of the rail at each RT and SPRT unit. The vertical and lateral loads shall be removed and the final position of the rail head shall be measured at each rail seat and recorded. The recorded values for lateral loads versus displacement shall be plotted on a graph.

b. The lateral displacement of the rail head when fully loaded shall not exceed 0.250 inches from the original gauge line. The difference between the original and final positions of the rail head shall not exceed 0.062 inches. At no time during the test shall a RT and SPRT component exhibit evidence of failure such as slippage, yielding or fracture.

11. Lateral Restraint Test

a. A static vertical load of 5,000 pounds shall be applied to the rail head midway between the RT and SPRT units. A lateral load shall then be applied at the base of the rail normal to the vertical load midway between the RT and SPRT units increasing in increments of 500 pounds from zero to 14,000 pounds at a rate of no less than 100 pounds per minute and no more than 500 pounds per minute. The lateral displacement of the rail head and rail base at each RT and SPRT unit shall be measured to the nearest 0.001 inch and shall be recorded after each increment of loading.

b. The lateral displacement of the rail head when fully loaded shall not exceed 0.125 inch from the original gauge line and the lateral displacement of the rail base shall not exceed 0.010 inch from the original gauge line. At no time during the test shall a component exhibit evidence of failure such as slippage, yielding or fracture.

c. Lateral boot stiffness. Repeat procedure 11.a, above, except

1) Measuring block lateral displacement to the adjacent support concrete.

2) Without a vertical load and

3) Limiting the maximum lateral rail base load to that of initial rail base uplift or 14,000 pounds, whichever is lower, then reduce the load incrementally while measuring the lateral block deflection at each increment.

4) Submit the recorded load and deflection data. The submittal approval will be on procedural compliance with load range, data (reasonably uniform curve) and accuracy. There is no pass/fail requirement.

12. Longitudinal Restraint Test

a. A load shall be applied longitudinally to the rail at its base increasing in increments of 500 pounds at a rate of no less than 100 pounds per minute and no more than 500 pounds per minute. Load increments shall be maintained constant for at least one minute before increasing the load to the next increment. The load shall be increased in these increments until slippage occurs between the RT and SPRT units and the rail. The longitudinal displacement of the rail shall be measured relative to the RT and SPRT unit nearest the load application point and recorded continuously to the nearest 0.001 inch from the time of initial loading, through rail slippage, to the time of rail unloading. The values for longitudinal load versus displacement shall be plotted on a graph.

b. The longitudinal load at slippage shall be equal to or greater than 5,000 pounds. At no time during the test shall a RT and SPRT component exhibit evidence of failure such as slippage, yielding or fracture except for the slippage between the rail fastenings and the rail.

13. Vertical and Lateral Repeated Load Test

a. A vertical load shall be applied to the rail head midway between RT and SPRT units to produce a vertical downward load of 40,000 pounds. A lateral load shall be applied to the gauge side of the rail head midway between RT and SPRT units to produce a load normal to the vertical load of 16,000 pounds. A second lateral load shall be applied to the field side of the rail head midway between RT and SPRT units to produce a load normal to the vertical load of 16,000 pounds. The lateral loads shall be applied 0.625 inch below the top of the rail. 100,000 cycles of vertical and field side lateral loading shall be applied first. Then 80,000 vertical load shall be applied with the 16,000 pound gage side lateral loading for 100,000 cycles. The load cycle frequency

shall be regulated to prevent the temperature of the components from exceeding 160 degrees Fahrenheit.

b. The RT and SPRT units shall withstand 100,000 cycles of load application in each direction with no evidence of failure. Upon visual inspection, no component of the RT and SPRT units shall exhibit evidence of failure such as slippage, yielding, abrasion, or fracture during the test. Unacceptable elastomer degradation is defined as the inability of the RT and SPRT unit to meet the post fatigue tests outlined in the qualification test matrix, 2. Adjusting or tightening of components shall not be permitted at any time during the test.

14. Voltage Withstand Test

a. The concrete slab shall be grounded. A direct current potential of 15 kV (or as high as achievable with the testing equipment if built-in safety features do not permit to reach 15 kV) shall then be applied to the rail head for one minute.

b. The elastomers shall withstand this test with no visible damage such as splits, cracks, pinholes or fracture.

15. Electrical Resistance and Impedance Tests

a. The concrete slab shall be grounded. A current potential of 750 volts DC shall be applied to the rail head for three minutes. The resistance shall be measured with an accuracy of plus or minus two percent.

b. The rail pad and insulators shall be removed from the assembled test configuration and immersed in distilled water for 70 hours at 95 degrees Fahrenheit. After removal from the water immersion, without drying, and with no portion of the soaked materials or RT and SPRT units at a temperature below 95 degrees Fahrenheit, the soaked materials shall be reinstalled. With the concrete slab grounded, 750 volts DC shall be applied to the rail head for three minutes. A potential of 50 volts AC shall then be applied to the rail head for three minutes for each increment of measurement for frequencies from 20 Hz to 10 kHz, in increments of 20 Hz up to 100 Hz, 200 Hz up to 1,000 Hz, and 2,000 Hz up to 10 kHz. The calculated impedance shall be based on plus or minus two percent accuracy and recorded for each frequency increment.

c. The minimum resistance for 750 volts DC shall be ten megohms when dry and 1 megohm when wet. The minimum impedance for any frequency between 20 Hz and 10 kHz with 50 volts AC shall be 10,000 ohms.

16. Rail Fastening Uplift Test

a. The configuration for the rail fastening uplift test is a single RT and SPRT unit rigidly restrained from uplift displacement with a rail section fully fastened to the RT and SPRT unit in accordance with the Supplier’s installation instructions. The rail fastenings from the second RT and SPRT unit shall be removed. The load application point on the rail shall be centered between the installed rail fastenings in a manner that will produce uniform loading to each fastening. An uplift load of 2,000 pounds plus the weight of the rail used in the test assembly shall be applied to the rail perpendicular to the rail seat. The

displacement of the rail relative to the RT and SPRT unit shall be measured continuously from initiation of loading through maximum loading to the full release of loading. Without resetting (i.e. without re-zeroing) the deflection measurement, the uplift load and release shall be repeated five times.

b. The position of all components after release of load shall be within the tolerances stated on the shop drawings. The rail fastening components shall not permanently deform. The difference in uplift displacement at 2,000 pounds between any one of the five repetitions of loading and the average total displacement of all repetitions shall not be greater than + five percent of the average total displacement. At no time during the test shall any RT and SPRT component exhibit evidence of failure such as slippage, yielding or fracture.

17. Tests Performed on Individual RT and SPRT Components

    a. Reinforced Concrete Blocks

        1) The Supplier shall produce eight test cylinders from a single pour of concrete used in the manufacture of the concrete blocks. The vibration of the casting machine or a vibrating table shall be used to compact the concrete in the molds. The molds shall be moist cured from the time of molding until the moment of test. The curing of the concrete cylinders shall be performed in accordance with ASTM C192/C192M or other equivalent specification. Four test cylinders shall be tested at seven days, two for compressive strength and two for flexural strength. If applicable four test cylinders shall be tested at or beyond 28 days, two for compressive strength and two for flexural strength. The flexural strength test shall be executed in accordance with ASTM C78/C78M (beams) or other equivalent specification.

        2) Compressive strength, Fc = 7000 psi

        3) Flexural strength, Ft = 700 psi

18. Concrete block tests

    a. The Supplier shall submit three concrete blocks of each type to the tests specified below.

    b. The dimensional tolerances shall conform to the approved shop drawings when measured with instruments or go/no go gauges as stipulated in the approved Contract Specifications.

    c. The concrete block shall be visually inspected for cracks, structural defects and surface finish.

    d. The concrete block shall not present cracks, structural defects, or surface finish defects incompatible with the satisfactory long term performance of the system.

19. Rail Fastening Tests shall not be performed before 28 days or a 7000 psi concrete compressive strength is achieved, whichever is sooner. The rail fastenings shall be subjected to the pull-out and torque tests described in Article 1.8 of this Section.

20. Positive Bending Moment Test

a. This test shall not be performed before 28 days or a 7,000 psi concrete compressive strength is achieved, whichever is sooner.

b. The configuration for the positive bending moment test shall be as shown in Figure 5.

c. The objective of this test shall be to record the load required to produce the first crack in the concrete block, and to evaluate the reinforcements' effectiveness in closing the cracks after the removal of the load.

d. Levels P1 and P2.

1) The concrete block shall be positioned under the press actuator and subjected to an initial load of 20,000 pounds.

2) The loading of the concrete block shall be progressively increased by 4,000 pounds increments. After each increment, the load shall be maintained for a minimum of one minute while both side surfaces of the concrete block are examined for the presence of cracks.

3) P1 shall be defined as the load required generating the first crack.

4) After P1 has been reached, the concrete block shall be subjected to successive zero-to-peak loading cycles. The peak load of each cycle shall be increased by a 4,000 pounds increment.

5) In each cycle, the load shall be gradually increased from zero up to the peak load. The peak load shall be held for a minimum of one minute before being fully released.

6) Once the load has been released, the width of the cracks on the side surfaces of the unloaded concrete block shall be measured and recorded.

7) The crack widths shall be measured at the level corresponding to the theoretical position of the lower reinforcement's centroid. If it is not possible to measure a crack at this level due to chipping of the concrete or surface imperfections, measurements shall be taken equidistant and as close as possible above and below this level; the two values shall be averaged to obtain the width of the crack.

8) P2 shall be defined as the peak load of the last cycle in which the widest crack on the concrete block is closed after the removal of the load. A crack whose width does not exceed 0.002 inch shall be considered to be closed.

e. Levels P3 and P4.

1) After reaching level P2, the incremental loading cycles shall be resumed.

2) P3 shall be defined as the peak load of the last cycle in which the opening of the widest crack on the unloaded concrete block is not greater than 0.02 inch.

3) After reaching level P3, the load shall be gradually increased until the ultimate failure of the rail concrete block.

4) P4 shall be defined as the maximum load carried by the concrete block.

f. Specified values for P2 and P3 are: P2[3] 40,000 pounds, P3[3] 60,000 pounds.

21. Block Pads

a. The Supplier shall supply nine block pads of each type for qualification testing. All nine block pads shall be subjected to the aspect, flatness and dimensional controls. Five block pads out of the aforementioned nine shall then be subjected to the static spring rate test followed by the static versus dynamic spring rate qualification test for two of them, the high and low temperature spring rate qualification test for one of them, the before versus after heat aging spring rate qualification test for another one and the before versus after fatigue spring rate qualification test for the last one.

b. The porosity test shall be performed on two of the remaining four block pads as well as on the block pad subjected to the fatigue spring rate qualification test, both before and after the completion of the fatigue test.

c. The last two block pads shall be subjected to the dynamic stiffness test.

22. The test block pad shall be visually inspected and found flawless and clean edged. Small surface defects, such as chips or blisters, shall, however, not constitute cause for rejection.

23. Flatness Control

a. A full block pad shall rest on a flat, level and smooth control surface. A straight, rigid rule shall be laid across the top surface of the pad along its length. The rule shall rest across the pad without compressing it.

b. The flatness shall be controlled at a minimum of three locations: one inch from each edge and at the centerline of the pad. The procedure shall be repeated with the rule placed along the width of the pad. If visible deformations exist in other locations, these locations shall be verified as well in accordance with the same procedure.

c. No gap or pocket between the rule and the top surface of the pad shall exceed 0.02 inch in depth or 0.80 inch in length.

d. The vertical distance measured from the bottom edge of the rule on either side of the pad (lengthwise and widthwise) and the control surface shall be in accordance with the thickness dimension and tolerance specified in the approved drawing of the block pad.

24. The dimensional tolerances shall be in accordance with the approved drawing of the pad.

25. Static Deflection Measurement, block support pad(s)

    a. This test shall be performed at room temperature (68 degrees Fahrenheit) on a complete block pad. For systems with multiple elastomeric members supporting the concrete block, this test shall be performed on each elastomeric member separately. Elastomeric members such as boots that require alteration for blocks to fully rest on the member shall be altered for test purposes to permit full block bottom extents to rest completely on the bottom portion of the elastomeric member.

    b. The loads shall be transmitted to the block pad through the block designed for each pad. Prior to the application of a load, the respective block shall rest with all its weight on the pad.

    c. Gauges, positioned at the corners of the loading block, shall be used to measure the deflection of the pad.

    d. The block pad shall be subjected to ten preloading cycles between 0 and 12,000 pounds at a rate of at least one cycle per minute but without creating internal pad heat

    e. The deflection gauges shall be set to zero after the deflection measurements have stabilized to within 0.001 inches from preload cycling.

    f. Loading shall be applied in increments of 2000 pounds to 12,000 pounds, measuring time and deflection at each load increment.

    g. Static Stiffness Acceptance Criteria:

        1) Spring rate shall be calculated using the deflections at loads of 4,000 pounds and 12,000 pounds. The test report shall have a table of all measured load and deflection data (at each 2,000 pound increment) and the time in milliseconds of each measurement.

        2) The static spring rates measured at 120 degrees Fahrenheit and 15 degrees Fahrenheit shall not differ from the static spring rate measured at 68 degrees Fahrenheit by more than 20 percent.

        3) The static spring rate measured at 68 degrees Fahrenheit after an artificial heat aging at 160 degrees Fahrenheit during 72 hours shall not differ from the static spring rate measured before the artificial heat aging by more than 30 percent.

        4) The static spring rate measured at 68 degrees Fahrenheit after 3 million fatigue loading cycles between near zero and 12,000 lbs. shall not differ from the static spring rate measured before the beginning of the fatigue test by more than 20 percent. The cycling rate shall ensure that overheating of the block pad does not occur.

26. Dynamic stiffness (dynamic spring rate)

    a. Configuration. The test shall be conducted using a single block of the configuration in Figure 4. Alternatively, the test may be conducted with a two blocks as in Figure 4 using double the specified loading, reporting the load as one half the actual applied load. In this test, downward loads and deflections are positive.

b. A full block assembly with all pads and rail fasteners shall be subjected incremental vertical loads of 2,000 pounds to 12,000 pounds, measuring deflections and pausing for one minute at each load increment. The static spring rate shall be calculated using the measured load and deflection at 4,000 pounds and 12,000 pounds. A table of all load, deflection and time of measurement shall be included in the report.

c. A vertical pre-load of 6,000 pounds shall be applied to the rail head. The deflection measurements shall be zeroed with the pre-load applied.

d. The block assembly shall then be subjected to cyclical loads between 0 and 12,000 pounds (6,000 pounds cyclic load amplitude). with the corresponding deflection shall be recorded at 0.005 second intervals for cyclic loading of ten Hz progressing in 20 Hz increments to 250 Hz, or the maximum stable test equipment frequency within the load range, whichever is less. A minimum of 20 load cycles shall be performed at each frequency. The first five and last five load cycles of each frequency's loading shall be ignored in computing dynamic stiffness.

e. The data (load, deflection, time) shall be recorded to a Microsoft Excel spreadsheet, with each cyclic data set saved in different electronic files. The dynamic stiffness shall be reported for each data set and the electronic files submitted on disk with the final test report.

f. Dynamic Stiffness and Damping Calculation:

$$k = \frac{F_0}{x_0\left[1 + \tan^2 \psi\right]^{1/2}} + m\,\omega^2$$

k = dynamic stiffness, lb/inch

x_0 = deflection peak amplitude, inch; maximum value in the sinusoidal variation with load (see Figure 1).

m= mass of the block and rail assembly, not including supporting base pads under the block. ***m*** = assembly weight/gravity constant = weight in pounds/386.4 inches/sec^2. Units: lb-sec^2/in

F_o= amplitude of the cyclic load, pounds = 12,000 – 6,000 = 6,000 pounds

ω= cyclic frequency (radians/sec). e.g. 10 Hz. cyclic loading is 20π radians/sec = 62.83 radians/sec

f = phase shift

$Tan\ \psi = \frac{TimeDelay}{Period}$; see Figure 1 for Time Delay and Period determination from measured data.

The assembly damping is calculated from *k*:

$$c = \frac{\left(k - m\,\omega^{2}\right)\tan\ \psi}{\omega}$$

Where ***c* =** Damping coefficient (lb-sec/in)

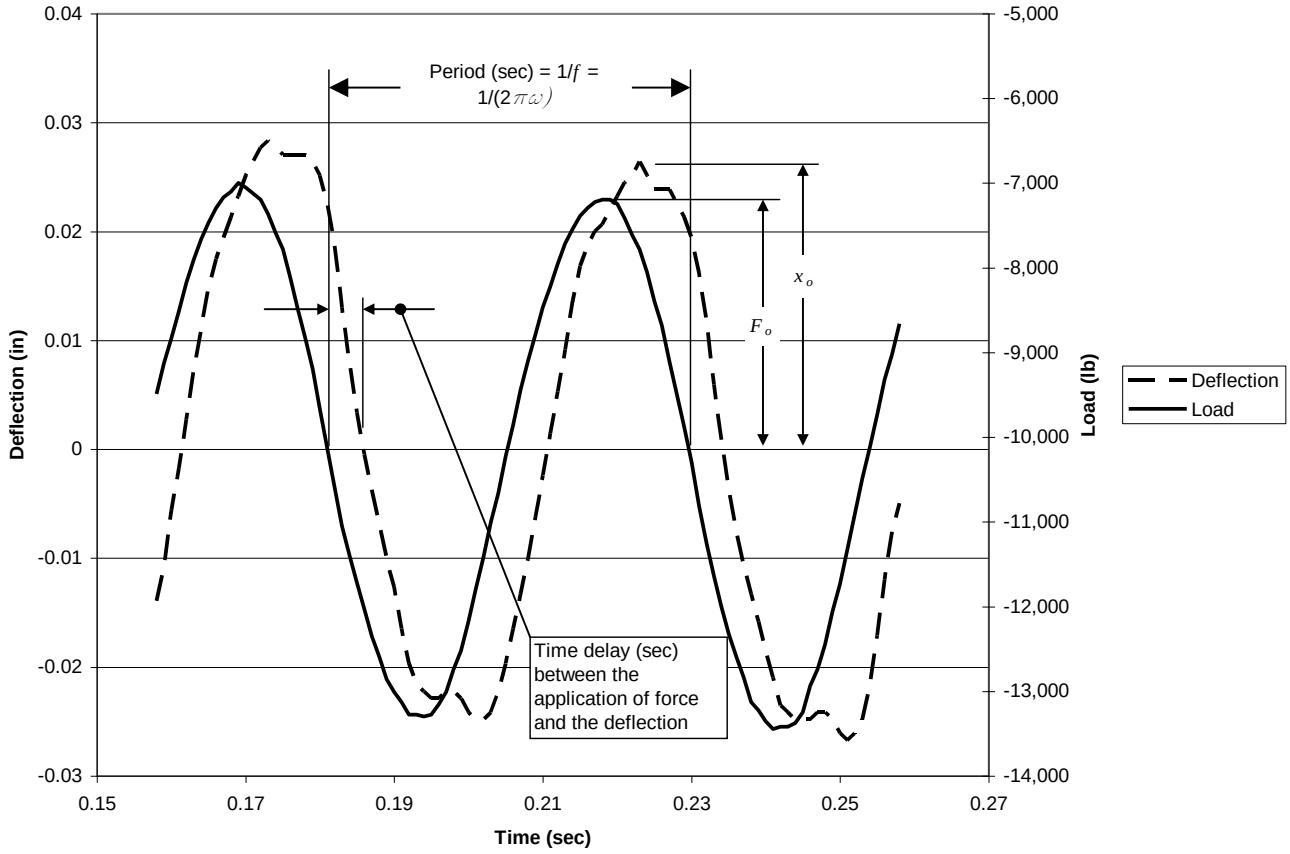


Figure 1 Illustration of Cyclic Load-Deflection Data for Determination of Dynamic Stiffness And Damping.

g. There is no acceptance criteria for dynamic stiffness or damping values. The acceptance of the submittal will be based on compliance to the procedure, and quality and accuracy of the data.

27. Ozone Test

a. The block pad material shall be exposed to 25 pphm ozone for 168 hours at 104 degrees Fahrenheit in accordance with ASTM D1149.

b. No cracks shall be apparent under a magnification of seven after exposure.

28. Porosity Test

a. This test shall be performed at 68 degrees Fahrenheit.

b. The initial weight (P0) of the block pads shall be measured and recorded.

c. The block pad shall be submerged in distilled water and compressed between two flat steel plates until the distance between the steel plates and therefore the thickness of the compressed block pad reaches 2/3 of the initial pad thickness. The block pad shall remain compressed during one minute. The block pad shall then be unloaded and maintained free of load for another minute. This cycle shall be repeated three times before the block pad is removed from the water.

d. The block pad shall be superficially dried and their weight P1 shall be measured and recorded immediately thereafter.

e. The difference between P1 and PO shall not exceed 0.07 ounces for any of the block pads tested.

29. Rubber Boots

a. The Supplier shall submit three rubber boots of each type to the tests specified below.

b. The rubber boot shall be visually inspected and found flawless and clean edged. Small surface defects, such as chips or blisters, shall, however, not constitute cause for rejection.

c. The dimensional tolerances of the rubber boot shall be in accordance with the approved drawing of the boot.

30. Measurement of the Shore A Hardness

a. The Shore A hardness of the boot material shall be measured according to ASTM D2240, indentation hardness of rubber and plastics by means of a durometer. Measurements shall be made at five points on the upper surface of the boot base.

b. The average of the measured Shore A values must fall between 70 and 80.

31. Measurement of the Ultimate Strength and Elongation at Break

a. Twelve samples (six longitudinal and six transversal) shall be cut from the base of the boot according to ASTM D412, method A, die C. The thickness of the samples shall correspond to that of the base of the boot.

b. The ultimate strength and the elongation at break shall be measured on six samples (three longitudinal and three transversal).

c. The remaining six samples (three longitudinal and three transversal) shall be artificially aged according to ASTM D573 for 72 hours in an oven maintained at a temperature of 212 degrees Fahrenheit + three degrees Fahrenheit. The ultimate tensile strength and the elongation at break shall be measured after cooling the samples at room temperature (+68 degrees Fahrenheit) for not less than 16 hours.

d. For each set, the median value of the three measures shall be recorded and the values shall meet the following:

1) Minimum tensile strength of the initial section before ageing 1740 psi and 1450 psi after ageing

2) Minimum elongation at break before ageing 250 percent and 180 percent after ageing

1.07 ANCHORAGE ASSEMBLIES QUALIFICATION TESTING (TURNOUT PLATE CONCRETE INSERTS)

A. For the acceptance of anchorage design, each anchorage assembly shall satisfy the test requirements and the test results shall not be averaged.

B. Test Preparation

1. The anchorage inserts or shoulder casting shall be embedded in a reinforced concrete test block. The test block size and configuration shall conform to one of the two test blocks shown in Figure 3. The size and configuration of the test block shall be determined by the Supplier, subject to approval by the District's Representative. The sides shall be vertical and the top and bottom shall be horizontal. The inserts and reinforcing steel shall be positioned as they would be in track. The inserts or shoulder casting shall be vertical, with the top face flush with the concrete surface. The inserts or shoulder castings shall be set in the concrete before or during the concrete placing. Post-drilling and placing of inserts or shoulder castings with resins or grouts shall not be permitted.

2. The concrete test block shall have a compressive strength of 4,000 to 6,000 pounds per square inch as determined by ASTM C39/C39M. The tests on the inserts or shoulder castings shall not begin until the concrete has reached the specified compressive strength.

3. The reinforcing steel shall be placed as shown on Figure 3. Use ASTM A615/A615M, Grade 60 steel.

4. The insert anchor bolts or shoulder casting test attachment shall be appropriately engaged for maximum test loading before load application.

5. The number of test blocks required to perform the anchorage assemblies qualification testing shall be determined by the Supplier, subject to approval by the District's Representative.

C. Qualification Tests

1. Eight anchorage assemblies identical in design to those specified for supply with the RT and SPRT shall be required to perform the tests specified herein.

2. Two separate anchorage assemblies shall be used for each of the three tests.

D. Restrained Pullout Test

1. Contact rail inserts, switch machine mounting bolt inserts

    a. Place a 8 inch by 8 inch by 1/2 inch steel plate with a 3 1/2 inch diameter hole in its center, centered over an anchor bolt. Apply for one minute an upward vertical load, starting at 1,000 pounds and increasing to 40,000 pounds, to the anchor bolt with the reaction force bearing against the steel plate. Repeat the test on one other anchor bolt.

    b. There shall be no evidence of slippage or cracking of concrete or failure of bond between either of the two bolts or inserts, and concrete.

2. Embedded Cast shoulder

    a. Place a 8 inch by 8 inch by 1/2 inch steel plate with a 3 1/2 inch square hole in its center, centered over an embedded shoulder. Alternative: Propose for Engineer approval a different load reaction plate suitable for the RT or SPRT tie design at a shoulder.

    b. Apply for one minute an upward vertical load, starting at 1,000 pounds and increasing to 40,000 pounds, to the embedded shoulder through a clevis, bolt or other suitable device through the shoulder's spring clip hole, with the reaction force bearing against the steel plate. Repeat the test on one other embedded cast shoulder.

    c. There shall be no evidence of slippage or cracking of concrete or failure of bond between either of the embedded shoulders or concrete embedment.

E. Unrestrained Pullout Test

1. Contact rail inserts, switch machine mounting bolt inserts

    a. Apply a vertical pullout load on an anchor bolt, in such a manner that no restraining load is applied to the concrete within a radius of six inches from the center of the bolt. The load application shall start at 1,000 pounds, be increased until a load of 12,000 pounds occurs, be held at 12,000 pounds for at least one minute and be released. Inspect the test block for evidence of concrete cracking or failure of bond between bolts or inserts, and concrete. Repeat the test on one other anchor bolt.

    b. After successful completion of the Unrestrained Pullout Test, reapply a vertical pullout load as specified in herein. The load application shall start at 1,000 pounds and be increased until fracture of the concrete test block. Inspect the anchor bolt and anchor insert for evidence of failure.

    c. There shall be no evidence of concrete cracking or failure of bond between either of the two bolts or inserts, and concrete when tested to a 12,000 pound pullout load.

    d. There shall be no evidence of insert fracture, or bolt or insert thread stripping when tested to fracture of the concrete test block.

2. Embedded Cast shoulder

    a. Apply a vertical pullout load on an embedded shoulder, in such a manner that no restraining load is applied to the concrete within a radius of six inches from the center of the bolt. The load application shall start at 1,000 pounds, be increased until a load of 12,000 pounds occurs, be held at 12,000 pounds for at least one minute and be released. Inspect the test block for evidence of concrete cracking or failure of bond between bolts or inserts, and concrete. Repeat the test on one other embedded shoulder.

    b. After successful completion of the Unrestrained Pullout Test, reapply a vertical pullout load as specified in herein. The load application shall start at 1,000 pounds and be increased until fracture of the concrete test block. Inspect the anchor bolt and anchor insert for evidence of failure.

    c. There shall be no evidence of concrete cracking or failure of bond between either of the embedded shoulders or concrete when tested to a 12,000 pound pullout load.

    d. There shall be no evidence of embedded shoulder fracture when tested to fracture of the concrete test block.

F. Torsion Test (contact rail mounting inserts and switch machine mounting bolt inserts, only)

1. An anchor bolt shall be subjected to a torque at least 100 percent greater than the design installation torque submitted with the installation requirements specified herein. The load shall be held for three minutes and released. Repeat the test on one other anchor bolt.

2. There shall be no evidence of failure of the bond between either of the two bolts or inserts, and concrete.

1.08 PACKAGING, LOADING, SHIPPING, AND HANDLING

A. The Supplier shall submit a Stockpile Plan to the District’s Representative for approval that defines how resilient ties and fastener components will be stacked and the area required.

B. Resilient ties shall be lifted and supported during manufacture, storage, transportation, loading, unloading, and stockpiling in a way which will prevent chipping, spalling, cracking, or other damage.

C. When resilient ties are stacked in multiple tiers, each tier shall be separated with dunnage having sufficient thickness to clear fastening shoulder inserts.

D. Resilient ties shall be uniformly vertically supported. All dunnage and separators shall in or align with the rail seat area.

E. Resilient ties sets required for special trackwork units shall be packaged separately and each shall be marked with the special trackwork unit identification number, unique color coding and location number. Complete resilient ties sets shall be first

sent to the manufacturing facility of the special trackwork, for required complete preassembly prior to shipment to the District.

PART 2 – PRODUCTS

2.01 DISTRICT-FURNISHED MATERIALS

A. There is no DFM.

2.02 SUPPLIER-FURNISHED MATERIALS

A. All products, tools, materials, equipment and labor required to complete all aspects of the work shall be furnished by the Supplier.

2.03 RESILIENT TIES

A. RTs and SPRTs shall be steel reinforced concrete fabricated in accordance with domestic industry practice.

B. RTs shall include concrete blocks with insulated rail fastenings consisting of embedded cast iron shoulders, drive on spring clips, plastic insulators and tie pads.

C. RTs for contact rail mounting shall also include threaded fastener inserts for 5/8 inch contact rail mounting bolts.

D. SPRTs for supporting Switch Machines shall also include threaded.

E. RT and SPRT Rail fasteners shall be BART DMP fasteners: Pandrol e2055 rail clip, Pandrol 3456/2 insulator, Pandrol 6902 tie pad and Pandrol 6575 embedded cast iron shoulder.

F. RT and SPRT design shall have the following characteristics:

1. Concrete block shall be surrounded on sides and bottom by a single piece molded rubber boot with conforming shapes.

2. Concrete block design shall be eight inch maximum depth from rail seat to bottom of tie.

3. Concrete block design shall hold gage, restraining vertical, lateral and longitudinal BART loads from unreinforced support concrete for a minimum of the bottom 2/3’s the tie block depth.

4. Concrete block and rubber boot sides shall be positively tapered to permit vertical removal/replacement without removing any bonding, concrete or fastening other than rail fastenings.

5. Concrete block, pads and rubber boot shall maintain their designed relationship under all service conditions without mechanical fastening or bonding.

6. The system shall have the capacity for lateral adjustment of one inch in either direction in adjustment increments of 1/4 inch.

G. SPRTs shall include insulated rail fastenings consisting of embedded cast iron shoulders, drive on spring clips, plastic insulators and pads. Threaded fastener inserts shall be provided for attachment of the switch machine and, when required by Contract Drawings, contact rail mounting.

1. Gage plates shall not be used.

2. Location and tolerances of turnout plates and inserts shall be in accordance with the manufacturer's drawings and specifications and shall yield the tolerances provided herein.

3. Threaded fastener inserts for switch machines shall be provided shall be the same type required for use for anchor bolts on direct fixation fasteners.

4. Resilient Ties supporting switch machines shall be one piece between the nearest running rail and the switch machine.

2.04 GENERAL PRODUCTION

A. Manufacture all resilient ties using the same methods used to produce qualification test pieces.

B. Fabrication of the block ties shall conform with applicable requirements of the AREMA Manual, PCI MNL 116, and applicable requirements of Chapter 30, Concrete Ties according to Manual for Railway Engineering.

C. Production of resilient ties or components prior to the District's Representative's review and approval is prohibited.

2.05 TWO-BLOCK TIE CONCRETE PRODUCTION

A. Concrete Quality:

1. Water content shall be kept to a minimum consistent with the strength requirements and placement needs. Concrete mixes shall be proportioned to produce a compressive strength of at least 7,000 psi when tested at 28 Days in accordance with ASTM C39/C39M.

2. The 28 Day flexural strength shall be at least 700 psi.

B. Concrete Mix Proportions:

1. Unless previous data are available to show that a concrete mix will be satisfactory for the production of concrete block ties, concrete mix designs shall be established by tests on trial batches to achieve the specified strengths. Mix designs shall be submitted to the District's Representative for review and approval.

2. The cement content shall not be less than 660 pounds per cubic yard.

3. Water-cement ratio shall not exceed 0.40 by weight and shall be calculated on the basis of the weight of cement.

4. Trial mixes using aggregate, water, cement, and admixtures proposed for the manufacture of concrete ties shall be made using at least three different water-cement ratios which will produce a range of strengths encompassing those specified herein. For each water-cement ratio, at least three specimens for each age to be tested shall be made, cured, and tested as hereinafter specified.

    a. Compressive strength tests shall be performed at 28 Days. A curve shall be established showing the relationship between water-cement ratio and compressive strength. The maximum permissible water-cement ratio for the concrete to be used shall be that shown by the curve to produce average strengths of 110 percent of those specified herein, provided the water-cement ratio shall be no greater than 0.40 when measured by weight.

    b. Flexural strength tests shall be performed at 28 Days as specified in Article herein for each trial mix.

5. The proportions of aggregate to cement shall produce a mixture which will work readily into corners and angles of the forms and around the reinforcement with the assistance of specified vibration, but without permitting the materials to segregate or excess free water to collect on the surface.

2.06 RT AND SPRT PRODUCTION TESTING

A. Production testing shall be performed at the manufacturer’s laboratory or, if such laboratory is not equipped to perform one or more of the tests specified herein, at a qualified outside laboratory.

B. If all the control and test results specified herein are satisfactory, the daily batch defined as all the concrete blocks of each type produced during one day shall be accepted. Any control or test failure shall cause the daily batch to be rejected.

C. Perform all production testing as provided herein for qualification testing.

D. Concrete Control Tests

1. Produce four test cylinders per production week.

2. Two test cylinders shall be tested at seven Days, one for compressive strength and one for flexural strength.

3. Two test cylinders shall be tested at 28 Days, one for compressive strength and one for flexural strength.

E. Two concrete blocks per daily batch shall be subjected to dimensional control.

F. Production aspect control shall be performed on all concrete blocks.

G. Fastening Tests

1. Perform pull out test shall be performed on one concrete block per daily batch.

2. Torque test for applicable RTs or SPRTs shall be performed on one concrete block per daily batch.

H. Positive Bending Moment Test

1. Rail seat positive bending moment test shall be performed on one concrete block per daily batch.

2. Every concrete block subjected to this test shall be tested up to level P2.

3. Only every tenth concrete block subjected to this test shall be tested up to level P4.

I. Block Pads

1. Unless otherwise agreed by the District's Representative, batches of block pads shall not exceed 3,000 units of standard plain line block pads and 300 units of all other types of block pads per batch when presented for inspection.

2. Three block pads per batch shall be randomly selected for each production control and test specified herein.

3. If the three control and test results are satisfactory, the batch shall be accepted.

4. If one result does not meet the requirements, the control or test shall be repeated on six additional randomly selected block pads.

5. If more than one of the first three or any of the additional six block pads do not meet the requirements, the batch shall be rejected.

6. The manufacturer shall, however, have the option to subdivide a rejected batch into 500 unit sub-batches and to repeat the controls and tests on each sub-batch using the same acceptance and rejection criteria as above.

7. The following controls and tests shall be performed as indicated herein.

    a. Aspect Control.

    b. Flatness Control.

    c. Dimensional Control.

    d. Porosity Measurements.

J. Rubber Boots

1. Unless otherwise agreed by the District's Representative, batches of rubber boots shall not exceed 3,000 units of standard plain line rubber boots and 300 units of all other types of rubber boots per batch when presented for inspection.

2. Three rubber boots per batch shall be randomly selected for testing.

3. If the three test results are satisfactory, the batch shall be accepted.

4. If one result does not meet the requirements, the test shall be repeated on six additional randomly selected rubber boots.

5. If more than one of the first three or any of the additional six rubber boots do not meet the requirements, the batch shall be rejected.

6. The Manufacturer shall, however, have the option to subdivide a rejected batch into 500 unit sub-batches and to repeat the tests on each sub-batch using the same acceptance and rejection criteria as above.

7. The following controls and tests shall be performed as indicated herein.

    a. Aspect Control.

    b. Measurement of the Shore A Hardness.

    c. Dimensional Control.

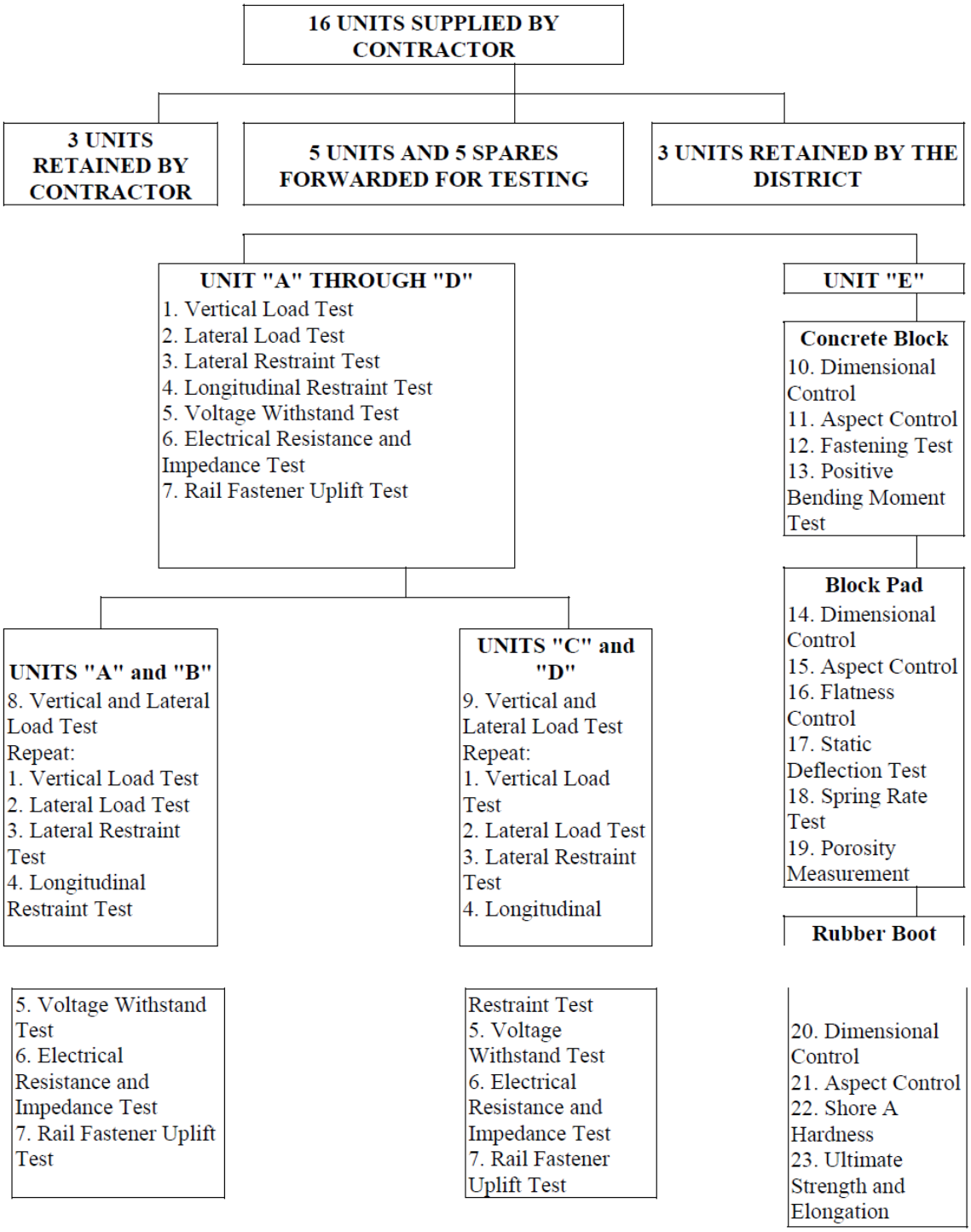
    d. Measurement of the Ultimate Strength and Elongation at Break.

PART 3 – EXECUTION

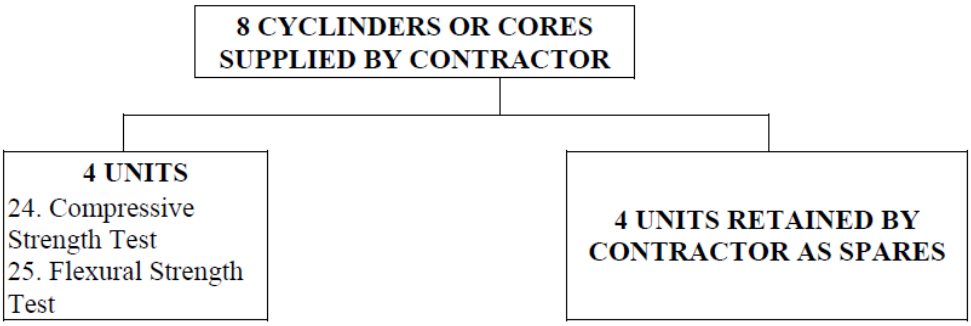
Not used

Figure 2 – RT AND SPRT QUALIFICATION TESTING SEQUENCE

PART A – RT AND SPRT UNITS



PART B - CONCRETE CYCLINDERS OR CORE



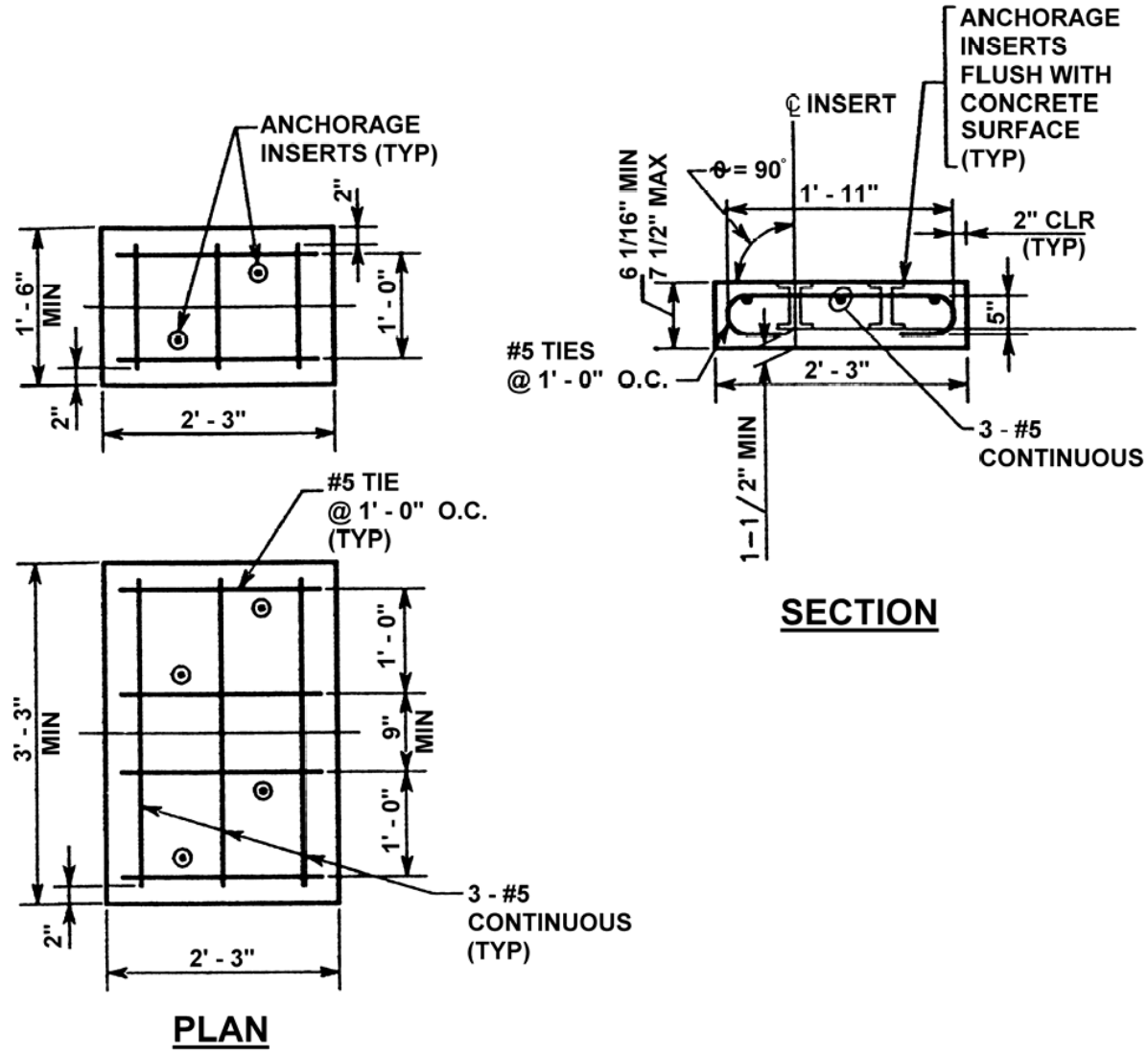


Figure 3. – CONCRETE TEST BLOCK FOR ANCHOR INSERT TEST

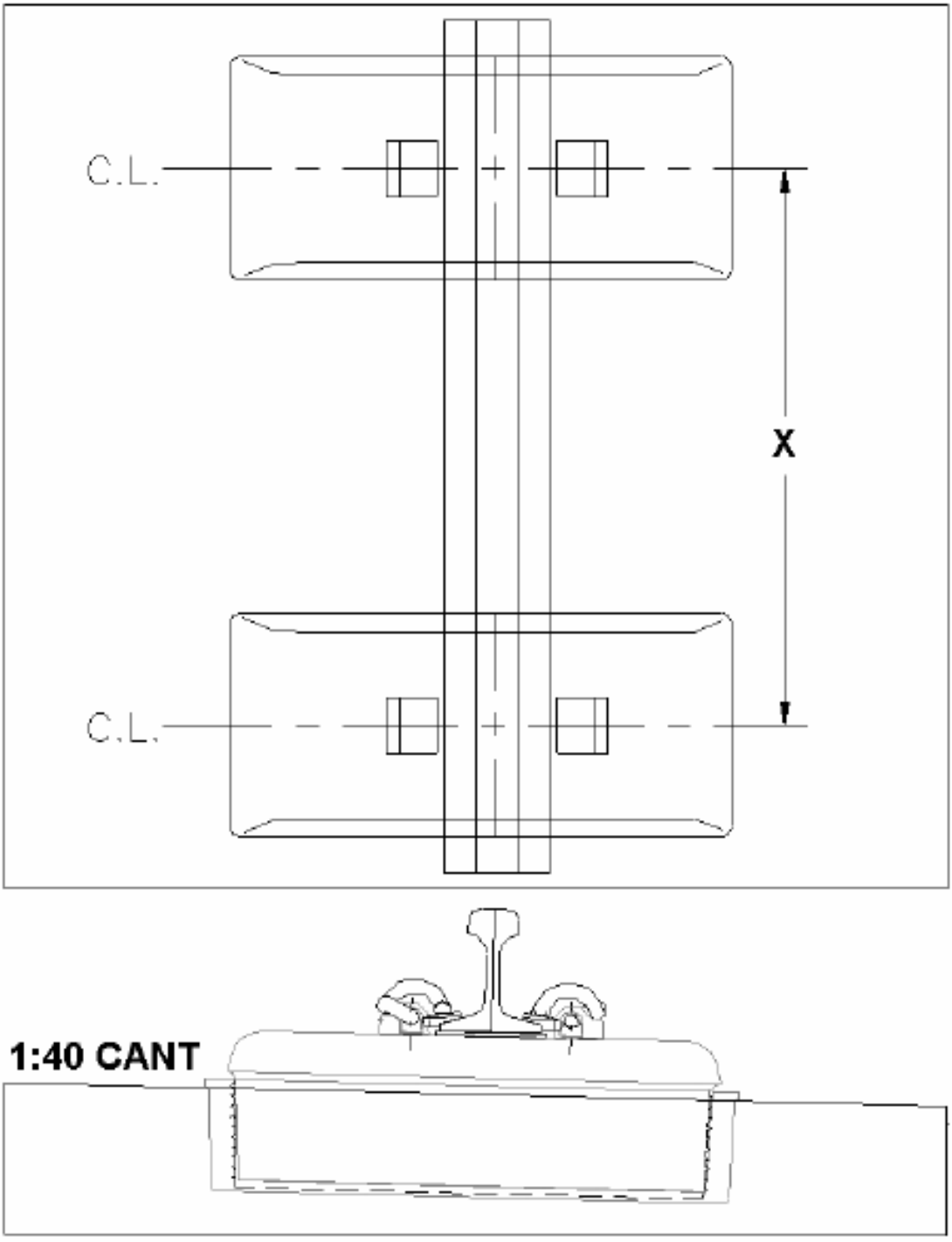


Figure 4 – RESILIENT TIE TEST ASSEMBLY

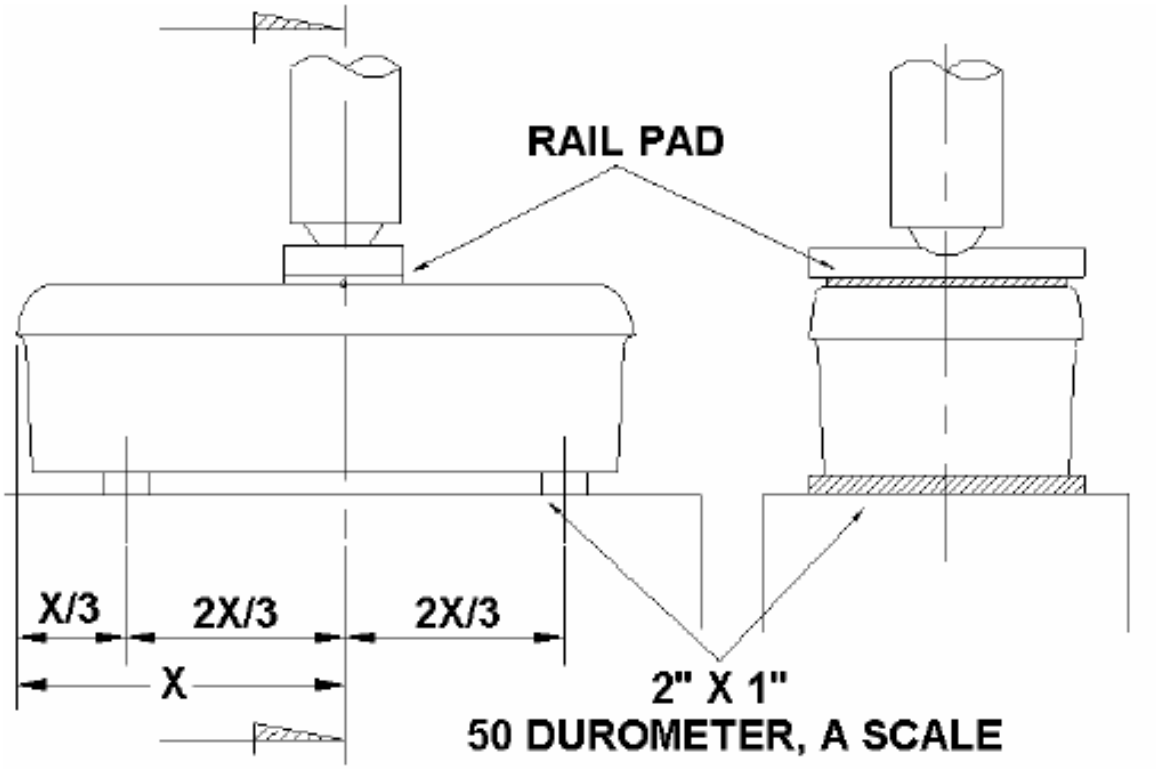


Figure 5 – RESILIENT TIE POSITIVE BENDING MOMENT TEST

END OF SECTION 34 11 32

SECTION 34 11 33

WOOD TIES

PART 1 – GENERAL

1.01 DESCRIPTION

A. This Section includes specifications for wood crossties and wood ties for special trackwork.

1.02 MEASUREMENT AND PAYMENT

A. Wood ties will not be measured separately for payment. All costs in connection therewith will be considered as included in the applicable Contract lump sum price or the Contract unit price per linear foot for trackwork of the different types indicated in the Bid Schedule of the Bid Form.

1.03 REFERNCE STANDARDS

A. American Railway Engineering and Maintenance of Way Association (AREMA): Except for modifications, amplifications, deletions, and additions indicated herein, as follows:

1. Volume 1, Chapter 30, Ties
2. Volume 2, Chapter 7, Timber Structures

B. American Wood Preservers Association (AWPA):

1. AWPA P1/P13 Standards for Creosote Preservative
2. AWPA P3 Standards for Creosote-Petroleum Solution

C. The Engineered Wood Association (APA):

1. APA A190.1 Standard for Wood Products - Structural Glued Laminated Timber

D. American Institute of Timber Construction (AITC):

1. AITC 109 Standard for Preservative Treatment of Structural Glued Laminated Timber

E. American Society of Mechanical Engineers (ASME):

1. ASME B18.21.1 Washers: Helical Spring-Lock, Tooth Lock, and Plain Washers (Inch Series)

F. American Society for Testing and Materials (ASTM):

1. ASTM B633 Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel

G. National Electrical Manufacturers Association (NEMA):

1. NEMA LI 1 Industrial Laminating Thermosetting Products

1.04 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Submittal Schedule:

Reference Item	Title	Article	Time Required
1.	Certificate of Conformance	2.02.B	Prior to Shipment
2.	Timber Treatment Report	2.02.B	Prior to Treatment
3.	Certificate of Compliance of Tie Pad	2.02.B	Prior to Shipment
4.	Wood Preservation Application	2.02.B	Prior to Application

1.05 QUALITY ASSURANCE

A. The cross-section of timber ties shall be plus or minus one fourth inch.

B. Ties shall be free of wayne.

C. Length shall be plus two inches or minus zero inches.

D. Wood shall be of compact wood throughout the tie, where any inch of any radius from the pith shall have six or more rings of annual growth.

E. Ties with large knot or numerous knots shall not be accepted. A large knot is one in which its average diameter exceeds one fourth of the surface on which it appears. Such a knot may be allowed if it occurs outside the tie plate area. Numerous knots are any number equaling one half of a large knot in damage effect.

F. The surface of a tie will be considered acceptably straight if:

1. When along the top and bottom surfaces, a string line stretched from mid-width at one end of the tie to mid-width at the either end of the tie within plus or minus one eighth inches of being truly straight, and;

2. When along each side a string line stretched from mid-depth of one end of the tie to the mid-depth of the other end of the tie is one eighth inches of being truly straight.

G. Ties shall be rejected if its surfaces are cut with score marks more than one eighth inch in depth or when its surfaces are uneven.

H. The top and bottom surfaces or opposite sides of a tie will not be considered parallel if any difference in tie thickness measured along the depth or along the sides exceeds one fourth inch, and shall be rejected.

I. Ties shall be free of bark seams.

J. Ties shall be free of twist in excess of one fourth inch per ten feet in length.

PART 2 – PRODUCTS

2.01 DISTRICT-FURNISHED MATERIALS

A. Refer to Section 01 64 13, District-Furnished Materials and Equipment, of the Contract Specifications for description and quantity of District-furnished materials.

2.02 CONTRACTOR-FURNISHED MATERIALS

A. Timber ties shall be manufactured from species identified as “Group Tb” in the AREMA manual and the follow requirements:

1. Size: Nine inches wide by seven inches deep

2. Lengths shall be provided as required in one foot increments.

3. The minimum cross tie length is ten feet.

4. The minimum special Trackwork Tie length is 12 feet.

B. Timber Quality Grade Marks and Certificates: All ties shall be grade marked, and a certificate of conformance provided, to indicate conformance with APA A190.1.

C. Preservative Treatment: Treat in accordance with the requirements of AITC 109 and the following requirements:

1. Treat using Grade #1 Creosote or 50-50 creosote-petroleum solution, to a final net retention of eight pounds per cubic foot.

2. The treatment provisions shall be modified to require one half inch minimum and three fourths inch average penetration.

3. The Contractor shall provide complete inspection of preservative treatment process and materials by an experienced independent testing agency approved by the Engineer. Each accepted tie shall be grade-marked by the testing agency,

and a report shall be prepared which includes a certificate of preservatives, an operating record of each charge, a record of retention and penetration, and a record of all ties rejected.

D. Wood Preservative: Provide an approved preservative formulated to treat holes drilled in timber ties. Submit manufacturer's recommendations for application.

E. Tie Plate Anchor Assemblies: All rail plates, switch plates, frog plates, guard rail plates, and derail plates shall be anchored and insulated with the following components as indicated on the Contract Drawings:

1. Timber Screw Spikes: Seven eighth inch diameter galvanized washer head square screw spike designated for railway service.

2. Plain Washer: Seven eighth inch diameter Type B, regular, in accordance with ASME B 18.21.1 Zinc-electroplated in accordance with ASTM B633. Type III, SC2.

3. Insulating Thimble: Press fit of a flat washer and sleeve fabricated of laminated thermoplastic conforming to NEMA LI 1, Grade G-10.

4. Tie Pad: One fourth inch thick polyethylene pads confirming to ASTM D1248, Type III, Class C, Grade W8, for high density weather resistant polyethylene plastic with a durometer hardness of 60 to 65D. The hardness shall be stable between 140 degrees Fahrenheit and minus 40 degrees Fahrenheit. Submit a certificate of compliance.

PART 3 – EXECUTION

3.01 GENERAL

A. Install wood ties in accordance with the requirements of Section 34 05 17, Common Work Results for Trackway; Section 34 11 23, Special Trackwork; and Section 34 11 27, Ballasted Track, except as modified herein.

B. Production of wood ties and fasteners components prior to the Engineer's review and approval shall be at the Contractor's sole risk and expense.

C. Manufacture using the same methods used to produce the qualification test pieces.

3.02 PRE-BORING

A. Drill 9/16 inch diameter pilot holes into timber ties for timber screw spikes to a depth limit of five inches, counter drill holes with seven eighth inch diameter hole for a depth of one inch, remove debris from holes, and fill holes with wood preservative. Pre-boring shall be perpendicular to the tie and centered in the tie plate hole. Only rail mounted rail tie boring machine specifically designed for this specific task shall be used, and shall include a centering nipple. Plates shall be clipped to the rail prior to drilling.

3.03 PLATE INSTALLATION

A. Place a tie pad under each steel plate, center plate on tie and clip plate to the rail. Position the palate with the field side shoulder parallel to and in uniform contact with the rail base. Plates shall be positioned for a minimum of ten ties prior to Pre-boring. After positioning the rail to correct alignment/gage, pre-bore one hole in each plate. Install insulating thimble, washer and screw spikes in the single pre-bored holes, taking care not to over-torque, causing variances in the track gage and alignment, pre-bore the remaining holes and insulating thimble, washer and screw spikes. Anchor with screw spikes, insulating thimbles and plain washers, as indicated, torqued to 90 foot-pounds.

3.04 HANDLING MATERIAL

A. Care shall be exercised in unloading and handling material to prevent breaing, gouging, bending or otherwise damaging material. Materials shall not be dropped nor thrown, but shall be lifted or skidded to the ground or other surface.

3.05 TOLERANCES

A. Construct within the specified track and special trackwork tolerances specified herein.

3.06 TIE INSTALLATION

A. Install Ties of the proper length. Field cutting of ties is not permitted and such ties shall be rejected.

B. Ties shall not be repetitively respiked. Ties requiring respiking more than one time shall be replaced at no additional cost to the District. All replacements shall meet all requirements specified herein.

C. Respiked ties shall first be retreated with preservatives, then the holes solidly plugged with properly shaped and treated plugs. Pre-boring of subsequent holes is required.

END OF SECTION 34 11 33

SECTION 34 11 37

DIRECT FIXATION FASTENERS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Standard Direct Fixation Fasteners (DF).

1.02 RELATED SECTIONS

A. Refer to Section 34 05 17, Common Work Results for Trackway, for related requirements.

1.03 MEASUREMENT AND PAYMENT

A. Direct fixation fasteners will not be measured separately for payment. All costs in connection therewith will be considered as included in the applicable Contract lump sum price or the Contract unit price per linear foot for trackwork of the different types indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. American Society of Mechanical Engineers (ASME):

1.	ASME B1.1	Unified Inch Screw Threads (UN and UNR Thread Form)
2.	ASME B1.3	Screw Thread Gaging Systems for Acceptability: Inch and Metric Screw Threads (UN, UNR, UNJ, M, and MJ)
3.	ASME B18.2.1	Square, Hex, Heavy Hex, and Askew Head Bolts and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws (Inch Series)
4.	ASME B18.21.1	Washers: Helical Spring-Lock, Tooth Lock, and Plain Washers (Inch Series)

B. American Society for Testing and Materials (ASTM):

1.	ASTM A153/A153M	Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
2.	ASTM F3125/ F3125M	Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 (830 MPa) and150 ksi (1040 MPa) Minimum Tensile Strength, Inch and Metric Dimension
3.	ASTM A36/A36M	Standard Specification for Carbon Structural Steel

4.	ASTM A536	Standard Specification for Ductile Iron Castings
5.	ASTM A615/A615M	Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
6.	ASTM A775/A775M	Standard Specification for Epoxy-Coated Steel Reinforcing Bars
7.	ASTM B117	Standard Practice for Operating Salt Spray (Fog) Apparatus
8.	ASTM B695	Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel
9.	ASTM C39/C39M	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
10.	ASTM D257	Standard Test Methods for DC Resistance or Conductance of Insulating Materials
11.	ASTM D297	Standard Test Methods for Rubber Products-Chemical Analysis
12.	ASTM D395	Standard Test Methods for Rubber Property-Compression Set
13.	ASTM D412	Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers-Tension
14.	ASTM D429	Standard Test Methods for Rubber Property-Adhesion to Rigid Substrates
15.	ASTM D471	Standard Test Method for Rubber Property-Effect of Liquids
16.	ASTM D573	Standard Test Method for Rubber-Deterioration in an Air Oven
17.	ASTM D624	Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers
18.	ASTM D1149	Standard Test Methods for Rubber Deterioration Cracking in an Ozone Controlled Environment
19.	ASTM D1193	Standard Specification for Reagent Water
20.	ASTM D1229	Standard Test Method for Rubber Property-Compression Set at Low Temperatures
21.	ASTM D1248	Standard Specification for Polyethylene Plastics Extrusion Materials For Wire and Cable

22. ASTM D1566 Standard Terminology Relating to Rubber

23. ASTM D2084 Standard Test Method for Rubber Property-Vulcanization Using Oscillating Disk Cure Meter

24. ASTM D2240 Standard Test Method for Rubber Property-Durometer Hardness

25. ASTM E10 Standard Test Method for Brinell Hardness of Metallic Materials

26. ASTM E23 Standard Test Methods for Notched Bar Impact Testing of Materials

27. ASTM E162 Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source

28. ASTM E662 Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials

29. ASTM F436/F436M Standard Specification for Hardened Steel Washers Inch and Metric Dimensions

C. National Association of Corrosion Engineers (NACE):

1. NACE SP0188 Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates

D. Society of Automotive Engineers (SAE):

1. SAE J429 Mechanical and Material Requirements for Externally Threaded Fasteners

2. SAE J434 Automotive Ductile (Nodular) Iron Castings

E. The Society for Protective Coatings:

1. SSPC-SP 1 Solvent Cleaning

2. SSPC-VIS 1 Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning

F. Rubber Manufacturers Association, Inc. (RMA):

1. RMA Publication Rubbers Handbook

1.05 SUBMITTALS

A. Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Refer to Section 34 05 17, Common Work Results for Trackway, for additional submittal requirements.

C. Provide additional submittals as required herein.

D. Submit design drawings, material specifications, laboratory test results, and fabrication procedures in sufficient detail to demonstrate conformance or equivalence with the Contract requirements herein.

1.06 DESIGN SUBMITTALS

A. Separate submittals are required for DF and SPDF fasteners.

B. Prior to manufacture of fasteners for qualification testing submit the following for review and approval.

1. Shop Drawings of each of the various fasteners, standard rail clip, special rail clip, anchorage assembly and shims, which detail each fastener component separately before assembly and the completely assembled fastener assembly. Drawings shall include all necessary dimensions, manufacturing tolerances and material descriptions for manufacturing the components as well as a table listing all components shown by name and by part number. Part numbers shall be assigned to fastener components and to finished assemblies. All parts identified by the same part number shall have the same physical dimensions, material composition, performance characteristics and durability.

2. Method for identifying each lot and fastener as detailed herein.

3. Installation and replacement procedures as detailed herein.

4. Manufacturing plan as detailed herein.

C. All submittals shall be made in accordance with the approved schedule to allow sufficient time for review and approval of resubmittals, if required, prior to manufacture of fasteners for qualification testing.

1. Preliminary Shop Drawings shall be submitted. Final Shop Drawings shall be submitted 30 Days prior to commencing qualification testing.

2. Lot and Fastener Numbering System.

3. Installation Procedure.

4. Manufacturing Plan.

D. Quality Program Plans.

1. Quality assurance/control plan as specified herein.

2. Test program plan as specified herein.

E. Qualification Test Results.

1. Submit the following for review and approval prior to commencing fastener manufacture.

    a. Certification of the elastomer samples used in qualification testing as detailed herein.

    b. Elastomer qualification test results for each test specified in herein.

    c. Anchorage assemblies qualification test results for each test specified in herein.

    d. Fastener body metal qualification test results for each test specified herein.

    e. Fastener assemblies qualification test results for each test specified herein.

2. Submit qualification test results within 14 Days after completion of testing. Submit elastomer certification with the elastomer qualification test results.

F. Production Test Results.

1. Submit the following for review and approval prior to shipping each fastener production lot.

    a. Certification of the elastomer samples used in the production testing of each production lot as detailed herein.

    b. Elastomer production test results for each test specified herein.

    c. Anchorage assemblies production test results for each test specified herein.

    d. Fastener production test results for each test specified herein.

2. Submit production test results within 14 Days after completion of testing. Submit elastomer certification with the elastomer production test results.

G. Submit the method of packaging, loading, shipping and handling the fasteners, rail clips and anchorage assemblies for review and approval prior to the initial shipment. Submit the methods no later than 60 Days prior to the initial shipment.

H. Submit record drawings, which incorporate all Engineer-approved changes into the fastener Shop Drawings, for review and approval within 15 Days of the final fastener delivery and prior to acceptance of the last product.

I. Submit sample DF and SPDF of each type and anchorage assemblies, complete with associated hardware and shims five Days prior to commencing qualification testing. Submit direct fixation fasteners and anchorage assemblies, and shims in the quantities indicated herein.

1.07 QUALITY CONTROL

A. The Contractor shall submit establish, implement and maintain a detailed Quality Plan in conformance with applicable requirements of Section 01 43 00, Quality Assurance, and Section 01 45 00, Quality Control.

B. In addition to the other requirements herein, the plan shall include the following:

1. Material specifications; certificates of compliance for all components.
2. Process control.
3. Quality control testing procedures and frequency.
4. Vendor (sub-supplier) surveillance.
5. Corrective action and disposition of defective components.
6. Delivery protection and handling.
7. Identification.
8. Acceptable quality levels and sampling plans.

C. Tolerances.

1. Manufacturing tolerances for the fastener shall be as shown in Table 1.

Table 1 - Direct Fixation Fastener Manufacturing Tolerances

DIMENSION	TOLERANCE
Length and width	± 1/16 inch.
Height	± 1/32 inch.
Squareness	All angles shall be within ± 0.5 degree.
Centering of holes	± 1/32 inch.
Diameter of holes	± 1/32 inch.
Durometer Shore A	± 5.
Serration depth	± 1/32 inch.
Serration spacing	± 1/32 inch.
Width between shoulders at rail base	± 1/32 inch.

Table 1 - Direct Fixation Fastener Manufacturing Tolerances	
DIMENSION	**TOLERANCE**
Rail seat area flatness measured from a straight edge placed across the rail seat area	Less than 0.050 inch.

2. Forming tolerances for the concrete test block used for fastener tests shall be as follows.

    a. The concrete surface flatness shall have a maximum one sixteenth inch gap between 16 inch straight-edge and concrete surface all around.

    b. The elevation of top face of anchorage insert embedded in concrete shall be zero inch above or 1/16 inch below top surface of concrete.

    c. No void in bearing surface of concrete shall be greater than a half inch and total area of voids shall be less than ten percent of total fastener bearing area.

D. Approval of the fastener design will be dependent upon successful completion of the qualification testing program specified herein.

E. All fastener testing and inspection shall be performed by a qualified, independent testing laboratory approved by the Engineer. The selected laboratory shall use the proper equipment and qualified testing personnel for the testing and inspection described in these Specifications. Fastener testing and inspection equipment and personnel shall be subject to approval by the Engineer. The Engineer, or an independent witness designated by the Engineer, will monitor the operations at the testing laboratory to ensure that the inspections and tests are being performed in accordance with approved procedures and in compliance with these Specifications.

F. Personnel performing tests and inspections shall be qualified for such work by virtue of prior experience or training.

G. Testing equipment shall be in good operating condition, of adequate capacity and range, and accurately calibrated. Testing equipment calibration shall be certified and traceable to recognized national standards such as the National Institute of Standards and Technology. Testing equipment shall be calibrated in accordance with the schedule in the approved Quality Plan specified in Section 01 45 00, Quality Control.

H. Test Program Plan.

1. A test program plan shall be prepared describing the approach for accomplishing each of the specified fastener inspections and tests. A detailed narrative shall be prepared for each test and inspection specified herein, describing the test set-up; equipment, and instrumentation that will be used; procedure to be implemented; and the anticipated, as well as acceptable test results. Drawings detailing test equipment and test set-up of fastener or fastener component that will be tested

shall be included. Drawings shall show the relationship of the fastener or fastener component and all significant components of the testing equipment, including the test block. Pertinent testing drawings included in industry standard specifications herein may be referenced in lieu of actual drawings. The test program plan shall include the test sequencing.

2. Equipment specifications and calibration methods for all testing equipment used to perform fastener testing and inspection shall be included in the test program plan. The plan shall indicate the calibration certificates that will be submitted with the test reports.

3. Identity and qualifications of personnel who will perform fastener testing and inspection shall be included in the test program plan. Also include certification records for personnel who will perform nondestructive testing.

4. The test plan shall include the name and location of the testing facility, qualifications of the testing facility, a description of the testing facilities, and a layout of the test equipment that will permit efficient performance of the testing.

5. The plan shall include the proposed format for reporting test data.

6. The projected schedule for test procedure submittals, test execution, and test result reports submittals shall be included in the test program plan.

7. The test program plan shall address qualification testing and production testing separately. Elastomer, anchorage assemblies, fastener body metal, and fastener assemblies shall also be addressed separately.

8. After approval of the test program plan, any proposed changes shall be approved by the Engineer prior to implementing the change.

I. Test Report.

1. A report of test results of each test shall be submitted which includes test name, identity of test sample, original data calculations, test procedure references, test equipment identification, test personnel, time and date of test, specified requirements, actual test results, non-conformances if any, and interpretation of the results. The format for the test report shall be arranged so that the data is presented in an orderly manner.

2. Accompanying the written test reports shall be a photographic record of the tests. The photographic record shall contain photographs of sufficient clarity to distinguish relevant details as described or referenced in the respective written report.

3. Copies of calibration certificates shall be submitted with the initial test results. If test equipment is recalibrated while work is being performed on this Contract, calibration certificates shall be submitted for the recalibrated test equipment with the test reports of the first tests performed after recalibration.

4. The Engineer shall be notified in writing not less than seven Days in advance of dates scheduled for any tests or inspections. The Engineer retains the right to witness the tests.

J. The Contractor shall prepare a manufacturing plan including.

1. An activity network delineating each step of production that will produce the fastener configuration shown on the approved Shop Drawings and made of the approved materials.

2. A narrative shall be included describing each activity. Special attention shall be given to key procedures such as curing temperature, curing time, molding pressure and heat treating.

3. A list of all company names and locations of any plant or subcontractors plant where work will be performed on any fastener or component part of any fastener. This list shall show what type or work function each company shall perform. Off the shelf, standard products such as bolts and nuts, need not show manufacturing location, but must show the company name and address from which it is proposed to be purchased.

1.08 DIRECT FIXATION FASTENER QUALIFICATION TESTING

A. General

1. Qualification tests shall be performed prior to fastener production to verify that the proposed fastener, fastener components, and fastener materials meet the requirements of these Specifications.

2. Test in accordance with the approved test program plan and test procedures.

B. Approval

1. All qualification tests conducted on fasteners, fastener components, and fastener materials shall be successfully completed to the approval of the Engineer prior to commencing any production of fasteners or fastener components.

2. After the Engineer has approved the fastener design, no change in the fastener design, fastener components, fastener materials, and manufacturing process shall be made without written approval of the Engineer. Should the Contractor propose a change, the Engineer may require retesting of the rail fastener as altered. All such testing shall be performed in the same laboratory on the same equipment and insofar as possible by the same laboratory personnel as the qualification tests.

1.09 ELASTOMER QUALIFICATION TESTING

A. Test Samples

1. Test samples shall be certified to have been taken from a batch of compound used for making the elastomer components of the fastener and having an equivalent degree of cure to the cure of the elastomer component.

2. Prior to testing, all samples shall be conditioned for not less than two Days or for the time period indicated in each specified ASTM standard, whichever is greater, at 23 degrees Celsius plus or minus two degrees Celsius and 50 relative humidity plus or minus five percent.

B. Perform the following tests on each of two specimens that are identical in all respects to the elastomer proposed for use in the direct fixation rail fasteners. Use a separate pair of specimens for each test.

C. Hardness Test

1. Measure the elastomer in accordance with ASTM D2240.

2. The durometer of the elastomer, measured on the Durometer A scale, shall be between 40 and 70.

D. Tensile Strength and Ultimate Elongation Tests

1. Test the elastomer in accordance with ASTM D412 to determine the tensile strength and the ultimate elongation.

2. The tensile strength shall be 2500 psi or greater and the ultimate elongation shall be 500 percent or greater.

E. High Temperature Compression Set Test

1. Test the elastomer for 22 hours in accordance with ASTM D395, Method B. The test shall be conducted at a temperature of 70 degrees Celsius.

2. The set shall not exceed 25 percent.

F. Compression Set at Low Temperature Test

1. Test the elastomer at minus 10 degrees Celsius for 70 hours in accordance with ASTM D1229, to determine the percent compression set at 30 minutes after release (t_{30} reading).

2. The compression set shall not exceed 65 percent.

G. Accelerated Aging of Rubber Test

1. Age the elastomer for 70 hours at 70 degrees Celsius in accordance with ASTM D573. Measure and record the change in hardness and percentage change of properties from the original tensile strength and ultimate elongation.

2. The percentage of decrease of tensile strength shall not exceed 25 percent; the percentage of decrease of ultimate elongation shall not exceed 25 percent; and

the change in hardness, measured on the Durometer A scale, shall not exceed 10 points.

H. Resistance to Ozone Cracking Test

1. Prepare test specimens in accordance with Procedure A of ASTM D1149. Test the specimens in accordance with ASTM D1149 at a temperature of 40 degrees Celsius and at an ozone concentration of 50 mPa.

2. The elastomer shall not exhibit any cracking when examined in accordance with ASTM D1149 at the end of a 100 hour exposure.

I. Oil Absorption Test

1. Determine the volume change of the elastomer using ASTM D471. Conduct one test with ASTM No. 3 oil at a temperature 23 degrees Celsius for 70 hours and conduct the other test using a different sample with ASTM No. 1 at a temperature of 23 degrees Celsius for 70 hours.

2. The volume change for the No. 1 oil shall not exceed 20 percent; and for No. 3 oil, the volume change shall not exceed 100 percent.

J. Adhesion to Metal Test

1. Test the elastomer's adhesion to the metal top and base elements as per ASTM D429 Method B. Use the same metal, metal preparation, elastomer, adhesives and bonding process in preparing the test specimen as are used in the production of the fasteners body.

2. The failure shall be a Type R, in which the elastomer tears before the elastomer bond to the metal parts fails. The adhesion value shall be a minimum of 35 pounds per inch width.

K. Flame Spread and Smoke Generation Test

1. Test the elastomer in accordance with ASTM E162 to determine the flame propagation index. Test the elastomer in accordance with ASTM E662 in both the flaming and non-flaming modes to determine the smoke generation specific optical index.

2. The elastomer shall not exhibit flaming drippings when tested. No acceptance criteria are specified for the flame propagation index and the smoke generation specific optical index. Report these indices to the Engineer for information only.

L. Electrical Resistivity Test

1. Test the elastomer in accordance with ASTM D257.

2. The elastomer shall have a minimum volume resistivity of 10^{12} Ω·cm.

M. Water Absorption Test

1. Determine the volume change of the elastomer due to absorption of water using ASTM D471. Use Type IV reagent water in accordance with ASTM D1193. Immerse the specimens for 70 hours at a temperature of 70 degrees Celsius.

2. The elastomer shall have a maximum increase in volume of five percent.

N. Tear Resistance Test

1. Test the elastomer in accordance with ASTM D624. Utilize Die C specimens.

2. The resistance to tearing shall not be less than 150 pounds per inch.

O. Rheology (Cure and Strength Indicator) Test

1. Test the elastomer in accordance with ASTM D2084.

2. During qualification testing a cure curve shall be developed based on the rheology test results for approval by the Engineer. Specification limits shall be established at several points along the curve for approval by the Engineer.

3. During production testing the cure curves shall be compared to the qualification test cure curve. The production test curve shall be within the specification limits.

P. Specific Gravity Test

1. Test the elastomer in accordance with ASTM D297.

2. During qualification testing the specific gravity of the elastomer shall be determined. During production testing the specific gravity shall be plus or minus 0.02 of the specific gravity determined during qualification testing.

1.10 ANCHORAGE ASSEMBLIES QUALIFICATION TESTING

A. For the acceptance of anchorage design, each anchorage assembly shall satisfy the test requirements and the test results shall not be averaged.

B. Test Preparation

1. The anchorage inserts shall be embedded in a reinforced concrete test block. The test block size and configuration shall conform to one of the two test blocks shown in Figure 2. The size and configuration of the test block shall be determined by the Contractor, subject to approval by the Engineer. The sides shall be vertical and the top and bottom shall be horizontal. The inserts and reinforcing steel shall be positioned as they would be in track. The inserts shall be vertical, with the top face flush with the concrete surface. The inserts shall be set in the concrete before or during the concrete placing. Post-drilling and placing of inserts with resins or grouts shall not be permitted.

2. The concrete test block shall have a compressive strength of 4,000 to 6,000 pounds per square inch as determined by ASTM C39/C39M. The tests on the inserts shall not begin until the concrete has reached the specified compressive strength.

3. The reinforcing steel shall be placed as shown on Figure 2. Use ASTM A615/A615M, Grade 60 steel.

4. The anchor bolts shall be threaded into the inserts to at least one and a half inch thread engagement before load application.

5. The number of test blocks required to perform the anchorage assemblies qualification testing shall be determined by the Contractor, subject to approval by the Engineer.

C. Qualification Tests

1. Eight anchorage assemblies identical in design to those specified for supply with the fasteners shall be required to perform the tests specified herein.

2. Two separate anchorage assemblies shall be used for each of the three tests.

D. Restrained Pullout Test

1. Place an eight inch by eight inch by one half inch steel plate with a three and a half inch diameter hole in its center, centered over an anchor bolt. Apply for one minute an upward vertical load, starting at 1,000 pounds and increasing to 40,000 pounds, to the anchor bolt with the reaction force bearing against the steel plate. Repeat the test on one other anchor bolt.

2. There shall be no evidence of slippage or cracking of concrete or failure of bond between either of the two bolts or inserts, and concrete.

E. Unrestrained Pullout Test

1. Apply a vertical pullout load on an anchor bolt, in such a manner that no restraining load is applied to the concrete within a radius of six inches from the center of the bolt. The load application shall start at 1,000 pounds, be increased until a load of 12,000 pounds occurs, be held at 12,000 pounds for at least one minute and be released. Inspect the test block for evidence of concrete cracking or failure of bond between bolts or inserts, and concrete. Repeat the test on one other anchor bolt.

2. After successful completion of the Unrestrained Pullout Test, reapply a vertical pullout load as specified in herein. The load application shall start at 1,000 pounds and be increased until fracture of the concrete test block. Inspect the anchor bolt and anchor insert for evidence of failure.

3. There shall be no evidence of concrete cracking or failure of bond between either of the two bolts or inserts, and concrete when tested to a 12,000 pound pullout load.

4. There shall be no evidence of insert fracture, or bolt or insert thread stripping when tested to fracture of the concrete test block.

F. Torsion Test

1. An anchor bolt shall be subjected to a torque at least 100 percent greater than the design installation torque submitted with the installation requirements specified herein. The load shall be held for three minutes and released. Repeat the test on one other anchor bolt.

2. There shall be no evidence of failure of the bond between either of the two bolts or inserts, and concrete.

1.11 BODY METAL QUALIFICATION TESTING

A. Charpy Impact Test

1. The Charpy impact test specified herein shall be performed on three samples of metal to be used for the metal top and base elements of the fastener body. Each metal sample shall have met the minimum impact requirements and be approved by the Engineer before fastener assembly qualification testing proceeds.

2. Prepare three Charpy impact test specimens in accordance with ASTM E23 from the same metal used for the top and base elements of the fastener body. If different grades of steel or iron are used for the two elements, prepare three specimens of each. Conduct a charpy impact test on each specimen at a temperature of 21 degrees Celsius in accordance with ASTM E23. The test report shall include all the information required by ASTM E23.

3. The fracture energy shall be greater than three foot-pounds for irons and 15 foot-pounds for steel.

B. High Frequency Resonance Test

1. Suspend the top plate with a nylon, hemp, polyethylene or cotton rope; or an elastomer band of sufficient strength to support the top plate without failure. Mount an accelerometer of mass not greater than 0.05 kg at the center of the rail seat area, with an axis of sensitivity normal to the rail seat. The accelerometer signal shall be appropriately conditioned with a charge amplifier or voltage preamplifier and analyzed with a minimum 400 line spectrum analyzer, while striking an end of the top plate with a hammer in a direction normal to the rail seat plane.

2. The frequencies of the top plate’s modes of vibration, identified by maxima in the spectrum of the response of the top plate to hammer impacts, shall be greater than 600 Hz.

1.12 FASTENER QUALIFICATION TESTING

A. General

1. Following review and approval of the Shop Drawings, installation procedure, manufacturing plan, test program plan and Quality Plan by the Engineer, a minimum of eight complete fastener assemblies and 12 shims shall be manufactured for qualification testing. From these, the Engineer shall select four fasteners and eight shims at random for testing. The selected fastener assemblies and shims shall be assembled and installed on the concrete test block for testing. The remaining four fastener assemblies and four shims shall be delivered to the Engineer to be retained for control reference of dimensional tolerances and surface appearance of fasteners subsequently manufactured and further test use.

2. If the two-fastener alternative testing arrangement is selected, the quantities of fasteners and shims required shall be revised. A minimum of 16 complete fastener assemblies and 24 shims shall be manufactured. From these, eight fastener assemblies and 16 shims shall be selected by the Engineer at random for testing, and eight fastener assemblies with eight shims shall be delivered to the Engineer.

B. Test Preparations

1. Except as described herein, a minimum of four complete fastener assemblies are required to conduct the tests. Each fastener shall be carefully measured and examined to determine their compliance with the approved Shop Drawings and these Specifications. Upon satisfactory completion of this measurement and examination, each fastener shall be assembled and designated as Fastener A, B, C, and D. Each fastener shall be mounted on a concrete test block and the tests conducted in sequence, in accordance with Figure 3.

2. Except as otherwise specified herein, each test shall be performed on a completely assembled fastener with a section of 119RE rail not less than one foot long mounted and clipped thereon. Before assembly, metal parts and elastomer shall be wiped clean and dry. The fasteners shall be assembled as shown on the test apparatus working drawings, as approved by the Engineer and as outlined in the approved test procedures. The fasteners shall be assembled with the rail in the middle lateral adjustment setting. One three-eighths-inch shim shall be placed under the fastener. The anchor bolts shall be tightened to the design installation torque submitted with the installation procedures approved by the Engineer. The torque of each bolt shall be measured and noted in the test report.

3. The concrete test block shall be one of the two test blocks herein, subject to approval by the Engineer.

4. Before commencing each test, the fastener and concrete test block shall be stabilized at a temperature of 23 degrees Celsius, plus or minus four degrees Celsius, for at least four hours, except as otherwise specified herein. Testing

shall be performed within the same temperature range, except as otherwise specified herein.

5. Except as otherwise specified herein, the test loading shall be applied to the rail at the centerline of the fastener. Each fastener shall be distinctly labeled and the test report shall clearly indicate the performance of each of the fasteners (Fastener A, B, C and D) separately. For acceptance of the fastener design, each fastener shall satisfy the test requirements without failure.

6. The number of test blocks required for the qualifications testing shall be determined by the Contractor, subject to approval of the Engineer.

7. Linear voltage displacement transducers may be used instead of dial gauges to measure displacements.

C. Alternative Test Preparations

1. Instead of using one fastener, each test may be performed on a pair of fastener assemblies with a section of 119RE rail not less than 30 inches long mounted and clipped thereon. The minimum edge-to-edge spacing between fasteners shall be six inches. Each fastener shall be assembled and mounted as described herein for one fastener. Fasteners shall be designated as Fastener A1 and A2, B1 and B2, C1 and C2, and D1 and D2. Tests shall be conducted in sequence in accordance with Figure 3.

2. For the two-fastener testing arrangement, the loadings specified for each test shall be doubled and applied to the rail at a point centered between the fasteners to ensure that each fastener is equally loaded. Each fastener in the pair shall be distinctly labeled and the test report shall clearly indicate the performance of each fastener (Fastener A1 and A2, B1 and B2, C1 and C2, and D1 and D2) separately. For the acceptance of fastener design, each fastener shall satisfy the test requirements without failure.

3. The concrete test block shall be prepared as herein, subject to approval of the Engineer.

D. The following tests shall be performed in the sequence shown on Figure 3.

E. Vertical Load Test

1. The fastener shall be vertically loaded to 18,000 pounds for one minute. Thereafter, the load shall be released, and, after one minute, displacement gauges, one on each side of the load, shall be zeroed at zero load. A vertical load increasing in increments of 1,000 pounds to a maximum load of 18,000 pounds at a rate not less than 100 pounds per minute and not more than 1,000 pounds per minute, shall be applied downward at the centerline of the rail head at the centerline of the fastener and normal to the rail. For each increment of load at 1,000 pounds and above, measure and record the vertical deflection of the rail head to the nearest 0.001 inch with each displacement gauge. The load shall be removed and the final position of the rail head measured and recorded to the nearest 0.001 inch with each displacement gauge.

2. Acceptance Criteria

   a. The fastener stiffness, defined as the slope of a straight line determined by standard linear least squares regression of the load versus deflection with load as the dependent variable, or response, and deflection as the independent variable over the load range of 4,000 to 12,000 pounds per fastener shall be within 15 percent of 108,000 pounds per inch. The tangent to the load versus deflection curve at each load between and including 4,000 pounds and 12,000 pounds shall be within 20 percent of the actual fastener stiffness determined above. For the purpose of calculation, the tangent to the load versus deflection curve at ($X_{n,}$ P_n) shall be approximated as: $(P_{n+1} - P_{n-1})/(X_{n+1} - X_{n-1})$; Where P_i is the load at deflection $X_{i.}$ The deflection X_i shall be the average of the two displacement gauge readings.

   b. The total compressive deflection of the elastomer at the 14,000 pounds load shall not exceed 25 percent of the uncompressed thickness. After removal of the maximum load of 18,000 pounds, the fastener shall return to within 0.005 inch of its original position within one minute. At no time during the tests shall a fastener component exhibit any sign of failure by slippage, abrasion, yielding, fracture, or bond failure. Slippage is defined herein to mean movement of any fastener component relative to its initial position not attributable to deflection of the elastomer.

   c. The values obtained when the test is repeated on same fastener, after performance of other tests shall meet the acceptance criteria specified herein and shall be within 15 percent of the initial test values.

F. Vertical Uplift Test

1. Continuously apply a vertical load of 2,000 pounds to the center line of the rail head at the centerline of the fastener normal to the rail, alternating continuously from a downward direction load to an upward direction load. The load shall be applied at a constant rate, between two and four minutes per cycle. Each cycle shall be from zero load to maximum compression, to maximum tension, and back to zero load. The fastener shall be preconditioned for not less than six complete cycles. After the preconditioning cycles, the test shall be run without pause for not less than ten complete cycles. The loads and corresponding deflections shall be continuously measured to the nearest 0.001 inch and immediately recorded on a load-versus-time graph and a deflection-versus-time graph, respectively. Recording shall be accurate within two percent of full scale readings. Remove the load and measure and record the final position of the rail head. The reaction force to the uplift load shall be applied to the test block on which the fastener is mounted. The test report shall include load-deflection, load-time, deflection-time, and calibration recordings.

2. Acceptance Criteria

   a. The vertical deflection of the fastener for an upward load of 2,000 pounds shall be within plus five percent to plus 135 percent of the deflection for the 2,000-pound downward vertical load. When the vertical load is continuously varied from vertical downwards to vertical upwards, there shall be continuity and uniformity of the load/deflection curve with no indication of backlash or

freeplay as the vertical load goes from downward directed to upward directed. After removal of the maximum upward test load and again after removal of the maximum downward test load, the rail head shall, within one minute, return to within 0.005 inch of its original rail head position. At no time during the test shall any fastener component, including the anchorage to the test block, exhibit any sign of failure by slippage, abrasion, yielding, fracture, or bond failure.

b. The values obtained when the test is repeated on same fastener, after performance of other tests, shall meet the acceptance criteria specified herein and shall be within 15 percent of the initial test values.

G. Lateral Load Test

1. While applying a constant vertical load of 14,000 pounds downward at the center of the rail head, a lateral load, increasing in increments of 500 pounds to a maximum load of 6,000 pounds at a rate not less than 100 pounds per minute and not more than 1,000 pounds per minute, shall be applied horizontally to the gauge side of the rail head at the point of vertical load. The horizontal force shall be applied 0.625 inch below the top of the rail. For each load increment the lateral deflection of the rail head at a point 0.625 inch below the top of the rail shall be measured to the nearest 0.001 inch and recorded. Remove the lateral load and measure and record the final position of the rail head.

2. Acceptance Criteria

a. The lateral load versus deflection curve shall lie within the envelope shown in Figure 4 for the operating range of 1000 to 4000 pounds of lateral load. After removal of load, the difference between the original and final position of the gauge line shall not exceed 0.062 inch. At no time during the test shall any fastener component exhibit a sign of failure by slippage, abrasion, yielding, fracture, or bond failure.

b. The values obtained when the test is repeated on same fastener, after performance of other tests, shall meet the acceptance criteria specified herein and shall be within 15 percent of the initial test values.

H. Lateral Restraint Test

1. Two equal lateral loads increasing simultaneously in increments of 500 pounds up to a maximum load of 3000 pounds shall be applied normal to the rail in the same direction and at the base of the rail. Loads shall be symmetrical on each side of the fastener centerline. The lateral deflection shall be measured to the nearest 0.001 inch at the intersection of the centerline of the fastener and the gauge line of the rail. Measurements shall be recorded after each increment of loading.

2. Acceptance Criteria

a. The difference between the original and final positions of the gauge line after removal of the load shall not exceed 0.062 inch. The lateral deflection of the rail when fully loaded shall not exceed 0.125 inch from the original gauge line

of the rail. At no time during the test shall any fastener component show signs of failure by slippage, abrasion, yielding, fracture, or bond failure.

b. The values obtained when the test is repeated on same fastener, after performance of other tests, shall meet the acceptance criteria specified herein and shall be within 15 percent of the initial test values.

I. Longitudinal Restraint Test

1. Apply a load longitudinally to the rail at its centroid increasing in increments of 200 pounds up to a total load of 4,000 pounds or until the rail deflects 0.6 inch from the initial position. Maintain each load increment constant until the longitudinal deflection of the rail ceases before increasing the load by the next increment. For each load, measure and record the longitudinal deflection of the rail to the nearest 0.001 inch. Then remove the longitudinal load and measure and record the final position of the rail. Plot the recorded values for longitudinal load versus deflection on a graph as shown on Figure 4.

2. The longitudinal load versus deflection curve, when plotted on a graph similar to Figure 4, shall lie entirely within the limits shown shaded. At no time during the test shall a fastener component exhibit a sign of failure by slippage, yielding, or fracture, except for the slippage that occurs between the rail clips and the rail.

J. Voltage Withstand Test

1. Prepare a fully assembled fastener and with a dc Hi Pot tester apply a dc potential of 10 kV between the rail head and the metal base element of the fastener body for one minute.

2. The elastomer shall withstand this test with no visible damage such as splits, cracks, pinholes or fractures. There shall be no evidence or arcing, arc tracking, or other voltage breakdown.

K. Electrical Resistance and Impedance Test

1. Prepare a fully assembled fastener and apply 500 V dc to the rail head for three minutes with all anchor bolts and metal base element grounded. Measure the resistance between the rail and anchor bolt, in accordance with ASTM D257, with an accuracy of plus or minus two percent and record. Next, remove the fastener from the test block and immerse it in deionized water for 70 hours at 70 degrees Celsius. Immediately after removal from the water immersion, without drying and with no portion of the fastener at a temperature less than 35 degrees Celsius, reinstall the fastener on the test block and test for electrical resistance and impedance. With all anchor bolts and the metal base element grounded, apply 500 V dc to the rail head for three minutes. Measure the resistance with an accuracy of plus or minus two percent and record. Apply a potential of 50 V ac to the rail head for three minutes for each increment of measurement for frequencies from 20 Hz to 10 kHz in increments of 10 Hz up to 100 Hz, 200 Hz up to one kHz, and two kHz up to 10 kHz. The impedance after three minutes shall be measured with an accuracy of plus or minus two percent and recorded for each frequency.

2. Acceptance Criteria

   a. The minimum resistance for 500 V dc shall be 10 MΩ when dry and one MΩ when wet. The minimum impedance for frequencies between 20 Hz and 10 kHz with 50 V ac shall be 10 kΩ when wet.

   b. The values obtained when the test is repeated on same fastener, after performance of other tests, shall meet the acceptance criteria specified herein.

L. Corrosion Test

1. The rail fastener, and all associated but unassembled components, shall be exposed to a five percent chloride solution in accordance with ASTM B117 for 500 hours.

2. Acceptance shall be based upon visual comparison between actual metal surface condition after completion of the test and the pictorial surface preparation standards presented in SSPC-VIS 1. The condition of the metal surfaces shall match or be superior to Rust Grade B, wherein there is no more than light surface rust, mill scale has only begun to flake. There shall be no evidence of edge bond deterioration. In areas where prior testing has removed the protective coatings, the surface rust grade specified above shall be used for judging acceptance.

M. Vertical and Lateral Repeated Load Test

1. Apply load on the rail head center so as to produce a vertical downward load of 14,000 pounds. Apply lateral loads to the gauge side of the rail head 0.625 inches below the rail head. Lateral loads shall be applied at the centerline of the fastener and normal to the rail. Lateral loads from the field side shall be 2,500 pounds and from the gauge side, 4,000 pounds. Application of the lateral loads shall be alternate, each combined with the application and release of the vertical load. Application of the field side load together with the vertical load, loads release and then the gauge side load together with the vertical load and loads release shall constitute one cycle. For the qualification testing program, the test shall be conducted for three million cycles. The anchor bolts may be retorqued to their initial torsion once during this test prior to 500,000 cycles. The loading frequency shall be regulated to prevent the temperature of components from exceeding 50 degrees Celsius. The rail clips shall not be repositioned nor threaded elements retorqued without written approval of the Engineer.

2. The fastener shall withstand the specified total number of cycles of load application with no evidence of failure. Upon visual inspection, no component of the fastener shall exhibit any evidence of failure by slippage, yielding, abrasion, fracture, or bond failure at any time during the test. The rail shall exhibit no evidence of wear or grooving that could contribute to failure of a rail. The rail clip shall not exhibit any evidence of vibrating loose from the rail clip holder.

N. Repeated Load Test With One Anchor Bolt Loosened

1. After completion of the vertical and lateral repeated load test, reassemble the fastener using only the original components previously tested. Then, with the gauge side anchor bolt loosened and backed out one fourth inch, repeat the vertical and lateral repeated load test for 15,000 cycles.

2. The fastener shall withstand the specified total number of cycles of loading with no evidence of failure by slippage, yielding, abrasion, fracture, or bond failure. The rail shall exhibit no evidence of wear or grooving that could contribute to failure of a rail. The rail clip shall not exhibit any evidence of vibrating loose from the rail clip holder.

O. Uplift Repeated Load Test

1. Test Method

   a. A fully-assembled fastener shall have loads applied to the rail head so as to produce alternately a vertical downward load of 14,000 pounds and a vertical upward load of 2,400 pounds at the centerline of the fastener normal to the rail. Apply the loads alternately for a total of 1.5 million complete cycles. The frequency shall be regulated to prevent component temperature reaching 50 degrees Celsius. Do not reposition rail clips nor retorque threaded elements without written approval of the Engineer.

   b. During the final 500,000 cycles, a longitudinal load shall be applied to the rail at its centroid. Increase the load in increments of 100 pounds up to 600 pounds at intervals of at least one increment per 100 cycles of vertical loading. For each load increment, measure and record the longitudinal deflection of the rail to the nearest 0.001 inch. Then remove the longitudinal load and measure and record the longitudinal position of the rail. Plot the recorded values for the longitudinal load versus deflection on a graph.

2. The fastener shall withstand 1.5 million cycles of load application with no evidence of failure. Upon visual inspection no fastener component shall exhibit any evidence of failure by yielding, abrasion, slippage, fracture, or bond failure. The rail shall exhibit no evidence of wear or grooving that could contribute to its failure. The plot of the load versus deflection curve shall indicate the elastic deformation and the residual deflection. The residual deflection shall not exceed 0.005 inch.

P. Dynamic to Static Stiffness Ratio Test

1. Test Method

   a. An oscillating downward load shall be applied at the centerline of the rail head at the centerline of the fastener so as to produce a sinusoidal load alternating between 2,000 and 6,000 pounds at a rate of between 10 and 20 Hz. The load and deflection versus time shall be continuously recorded on a high speed oscillograph. After a minimum of 1,000 cycles, the dynamic stiffness shall be determined from the ratio of peak-to-peak force to peak-to-

peak deflection from the recorded information. The deflection shall be measured to an accuracy of 0.001 inch or better.

b. Between five and ten minutes after completion of the dynamic stiffness measurement, a vertical load increasing in 1,000-pound increments to a maximum load of 6,000 pounds, at a rate not more than 1,000 pounds per minute, shall be applied at the centerline of the rail head at the centerline of the fastener. For each increment of load between 2,000 and 6,000 pounds, record the vertical deflection of the rail head to the nearest 0.001 inch. The static stiffness of the fastener shall be the difference in load divided by the difference in deflection between 2,000 and 6,000 pounds.

2. The dynamic stiffness shall not exceed one and a half times the static stiffness.

Q. Heat Aging Test

1. Age test the fastener body, without rail, concrete test block, rail clips or anchorage assemblies in an air oven. The fastener body shall be aged for 336 hours at a temperature of 70 degrees Celsius as per ASTM D573.

2. This is a conditioning process and there is no acceptance criterion.

R. Fastener Qualification Failure

1. Should any fastener assembly fail a test, the entire sequence of tests, as specified, in which the failed test is included, shall be performed on a new fastener assembly.

2. If the fastener assembly must be modified to pass any test, Shop Drawings of the new design shall be submitted and approved by the Engineer before qualification testing is continued.

3. A new lot of at least eight rail fastener assemblies of the new Engineer-approved design shall be produced and all tests performed on the new fastener design.

4. The revision, approval and test cycle shall continue until fastener assemblies are approved, but no longer than 12 weeks after acceptance of the new design.

5. The cost of all such additional designing, manufacturing, and testing caused by failure of any component that does not comply with these Specifications, including expenses for the Engineer to witness the tests, shall be at no additional expense to the District.

1.13 PACKAGING, LOADING, SHIPPING, AND HANDLING

A. The Contractor shall submit a stockpile plan to the Engineer for approval that defines how the direct fixation fasteners and fastener components will be stacked and the area required.

B. Direct fixation fasteners shall be lifted and supported during manufacture, storage, transportation, loading, unloading, and stockpiling in a way that will prevent tearing, separation, deformation, or other damage.

C. Direct fixation fastener sets required for special trackwork units shall be packaged separately and each shall be marked with the special trackwork unit identification number, unique color coding and location number. Complete tie sets shall be first sent to the manufacturing facility of the special trackwork, for required complete preassembly prior to shipment to the District.

PART 2 – PRODUCTS

2.01 DISTRICT-FURNISHED MATERIALS

A. Refer to Section 01 64 13, District-Furnished Materials and Equipment, of the Contract Specifications for description and quantity of District-furnished materials.

2.02 CONTRACTOR-FURNISHED MATERIALS

A. All products, tools, materials, equipment and labor required to complete all aspects of the work shall be furnished by the Contractor.

2.03 PRODUCTS AND MATERIALS

A. The same brand, type, and style of fasteners shall be used throughout.

B. Fastener Dimensions

1. When completely assembled with clips and anchors all parts of the fastener above the concrete trackbed shall stay within a design envelope fourteen and a half inches long minimum and 16 inches long maximum, measured horizontally perpendicular to the rail; and seven inches wide minimum and eight inches wide maximum, measured horizontally parallel to the rail. SPDF rail fastener lengths may vary, as recommended by the manufacturer, up to 72 inches long; the minimum number of different lengths shall be minimized.

2. The height of the fastener body in the installed position measured vertically from the base of the fastener body to the base of rail at the rail centerline and excluding shims shall be no greater than two inches.

3. No portion of the completely assembled fastener, including rail clips and anchor bolts, shall extend any higher than four inches measured vertically from the base of rail at the rail centerline.

4. The perpendicular-to-rail offset from centerline of anchor bolt to centerline of fastener shall be five and one fourth inches. The parallel-to-rail offset from centerline of anchor bolt to centerline of fastener shall be one and three fourths inches. In addition, the centerline of anchor bolt shall be no closer than one and a half inches from any side.

5. When installed, no part of the anchorage insert shall extend into the track concrete deeper than five and a half inches from the concrete trackbed surface.

6. The diameter of the fastener body and anchorage assembly component holes through which the anchor bolt passes shall not be less than 0.895 inch nor more than 0.938 inch.

7. With the rail clips removed from the otherwise assembled fastener, no portion of the fastener shall extend any higher than one and a half inches above the base of rail, as measured vertically from the base of rail at the rail centerline.

8. These and other dimensional requirements are shown graphically on Figure 1.

C. Specific Fastener Requirements

1. The fasteners shall be for use with 119RE continuously welded running rail, jointed rail, within special trackwork and insulated rail joints.

2. The fastener shall consist of as few components as economically and technically feasible for ease of assembly, disassembly and maintenance in the field.

3. The anchor bolt shall be capable of being removed and installed using a socket wrench or vertical bolting machine, without removing the rail clip.

4. When installed in track it shall not be necessary to raise the rail more than one and a half inches to remove or install the fastener.

5. Welding shall not be used in the fabrication or assembly of the fastener nor any fastener component.

6. Except for SPDF fasteners used under switch points and stock rails, there shall be no specific field or gauge side to the fastener.

7. Longitudinal restraint properties of the fastener shall be identical in both longitudinal directions. Lateral restraint properties of the fastener shall be identical in both lateral directions.

8. Rail fastener shall provide a means of adjusting the rail laterally within a range of plus or minus one inch in increments of one eighth-inch or less. The lateral fastener adjustment shall be integral with the fastener anchorage assembly. Lateral or longitudinal stability of the rail shall not be reduced in any adjustment position. All requirements of these specifications shall be satisfied for all increments of adjustment of the fastener. Friction alone shall not be used as a means of adjustment. Lateral adjustment shall be by a method that does not require removal, substitution or addition of any fastener components.

9. If serrations are used for lateral rail adjustment, not less than three interlocking serrations shall be engaged in any position of lateral adjustment. The bottom plate serrations shall be an integral part of the bottom plate.

10. A lot and fastener numbering system shall be developed for marking each fastener. A lot number, daily production identification number, and manufacturer’s name or trademark shall be permanently and clearly stamped or molded on the top of each fastener. The marking shall be readily visible in the

installed position. The location and method of marking of identification data shall be shown on the Shop Drawings.

D. Fastener Body Requirements

1. The rail fastener body shall consist of an elastomeric pad bonded between metal top and base elements. Bonding shall use the vulcanization process.

2. The metal top and base elements shall be designed with sufficient material strength, thickness and shape to withstand the loading requirements of the specifications and the transit system.

3. The metal top element shall have a flat rail-bearing surface in the center of the fastener that supports the rail directly without intermediate pads or shims beneath the rail and without rail cant. The rail seat area shall be flat to provide a uniform bearing surface. The rail shall rest on the rail seat without rocking, or other indications of non-uniform mating between the rail base and the rail seat surface with rail clips removed.

4. Shoulders which position and secure the rail against lateral movement, both with and without the rail clips installed, shall be integral with the metal top element along the entire rail bearing surface and shall be set parallel on both sides of the rail base. Width between shoulders at the rail base shall be five and nine sixteenths inches.

5. The bottom of the fastener shall be parallel to the rail seat so as to provide no cant to the rail.

6. The bottom of the fastener shall be flat and without any downward projections.

7. The stability of the rail fastener in any lateral and longitudinal direction shall not be solely dependent on the strength of the bond of the elastomer to metal.

8. The fastener’s metal top and base elements shall have full bearing on the elastomer pad in all positions of lateral fastener adjustment.

9. The fastener design shall be such that the elastomer is fully bonded to all parts except for the detachable components.

10. Bonding of any part of the fastener to the rail or track concrete is prohibited.

11. All metal surfaces of the fastener body’s top and bottom elements that are not covered with elastomer shall be coated with the adhesive used to form the bond of elastomer to metal.

12. The bottom of the base element shall be free of elastomer except that minimal flashing of bonded elastomer, not exceeding one thirty-second of an inch in thickness, will be acceptable providing it does not interfere with retention of proper anchor bolt tension nor otherwise interfere with the performance of the fastener.

13. The rail seat area of the top element shall be free of elastomer except that minimal flashing of bonded elastomer, not exceeding 1/32 inch in thickness, will be acceptable providing it does not interfere with the performance of the fastener, and it allows full contact of the rail with the rail seat.

14. Except within the rail seat area and on the fastener bottom, loose, unbonded flash not extending out greater than a quarter of an inch from a bonded surface, will be allowed.

15. The elastomer pad shall not be thinner than five eighths inch.

16. The load deflection on SPDF fasteners of the elastomer shall not exceed 25 percent of its uncompressed thickness for a load of 15,000 pounds applied vertically to the rail in a fully assembled rail fastener. Precompression of elastomer in rail fasteners in the installed position shall be included in determining the total compressive strain.

17. No mechanical metal distortion during the molding process is allowed.

18. Polyethylene base pads indicated shall conform with ASTM D1248, Type III, Class C, Grade W8, for high-density polyethylene plastic with a durometer hardness of 60 to 65D. The hardness shall be stable between plus 140 degrees Fahrenheit and minus 40 degrees Fahrenheit. Submit a certificate of compliance.

E. Fastener Anchorage Assembly Requirements

1. DF fastener bodies shall be secured to the track concrete with two anchorage assemblies, one on each side of the rail. The anchorage assemblies shall be located as shown in Figure 1. Each anchorage assembly shall consist of an anchor bolt, anchorage insert, lock washers, washers and other components required for lateral adjustment of the fastener.

2. SPDF fastener bodies shall be secured to the track concrete with four anchorage assemblies, two on each side of the fastener. Each anchorage assembly shall consist of an anchor bolt, anchorage insert, lock washers, and washers. Other components required for lateral adjustment of the fastener shall be provided. Lateral adjustment feature of the fastener shall be a part of the fastener anchorage assembly.

3. The anchorage assembly shall anchor the metal base element to the track concrete, with a seven eighths inch diameter anchor bolt. The anchor bolt shall be threaded into a female-type anchorage insert embedded in the track concrete perpendicular to the fastener base. Anchor bolts shall not penetrate the metal top element.

4. The fastener shall provide a means of adjusting the rail laterally within a range of plus or minus one inch in increments of one eighth inch. The means of lateral adjustment shall be integral with the fastener anchorage system and shall not require removal, substitution or addition of components. Lateral adjustment shall also not require the movement of an anchor bolt laterally. Friction alone shall not be used as a means of adjustment. Lateral or longitudinal stability of the rail shall

not be reduced in any adjustment position. All requirements of these specifications shall be satisfied for all increments of adjustment of the fastener.

5. The anchorage assembly shall not permit more than one eighth inch total lateral movement of the fastener relative to the concrete trackbed when the anchor bolts are finger tight.

6. Serrations used for lateral rail adjustment, not less than three interlocking serrations shall be engaged in any position of lateral adjustment. The bottom plate serrations shall be an integral part of the bottom plate.

7. The anchor bolt shall be capable of being removed and installed, using a socket wrench, without removing the rail clip.

8. Each anchorage assembly shall require a lock washer.

F. Electrical Insulation Requirements

1. The fastener design shall provide a three quarters of an inch minimum electrical leakage distance under all load and adjustment conditions. The electrical leakage distance shall be measured from any grounded portion of the fastener to any charged portion of the fastener by the most direct path that does not pass through insulating material. The leakage distance path shall exclude recesses and other geometric configurations that are susceptible to collecting and holding moisture, dust, and other electrically conductive materials.

2. Recesses or notches which penetrate the metal top element and expose the elastomer shall be free draining at all values of track superelevation from zero to eight and a quarter inches if draining in a direction perpendicular to the rail and at all values of track profile grade from zero to four percent if draining in a direction parallel to the rail.

3. Fastener surfaces shall be resistant to conductive oil and dirt buildup and facilitate effective periodic cleaning by track maintenance equipment and personnel.

4. Exposed metal surfaces on the sides of the fastener shall be covered by at least a 1/16 inch of the same elastomer as used in the fastener body. The elastomer covering shall be securely bonded to the metal surfaces during the same vulcanization process as the rest of the elastomer.

5. The minimum resistance for 500 V dc shall be 10 MΩ when dry and 1 MΩ when wet.

6. The minimum impedance for frequencies between 20 Hz and 10 kHz with 50 V ac shall be 10 kΩ when wet.

G. Vibration Isolation Requirements

1. The rail fastener shall be designed to attenuate vibration forces transmitted to the concrete trackbed by vehicle operation on the rail.

2. The elastomer used to attenuate vibration forces shall be fully bonded to both the metal top element and the metal base element. Separate resilient pads placed between rail base and the fastener rail seat or between the fastener base and concrete trackbed, or separate elastomeric washers under the anchor bolt, shall not be permitted.

3. The vibration isolation performance of the fastener shall not be compromised in any position of lateral adjustment.

4. Dimensions affecting the shape of the elastomer in the fastener shall be determined by the manufacturer so that the complete rail fastener conforms to the physical requirements and acceptance criteria for all fastener tests.

H. Fastener Installation

1. The anchor bolt shall be capable of being removed and installed, using a socket wrench or vertical bolting machine without removing the rail or rail clips. Special tools developed to perform a unique function related to the fastener or not available from commercial sources shall not be permitted.

2. For height adjustment during installation, one or two shims of variable thickness shall be placed by the installer between the fastener base and the concrete trackbed to provide for vertical adjustment to compensate for construction tolerances and variations. The nominal design thickness of the shim shall be three eighths inch. The Contractor may vary the shim thickness from a minimum of an eighth of an inch to a maximum of one half inch in one sixteenth inch increments. The shims shall be high-density polyethylene conforming to the specifications herein. The Contractor shall provide all shims, including those shims required for fastener testing.

3. The Contractor shall place the fasteners upon a 1:40 canted reinforced concrete trackbed. The concrete will have a 28 day compressive strength of 4,000 pounds per square inch. The female-type anchorage inserts will be cast into the concrete during the pour spaced beforehand to match the anchor design of each fastener and fastener spacing along each rail. They will be set perpendicular to the top of the track concrete so that the top face of the insert is flush with the top surface of the concrete. The Contractor shall ensure that the top surface of the concrete is flat and free of cavities and voids. Concrete forming tolerances will match those required of the concrete test block for the fastener tests. Bonding agents for application to base of fastener, to shims, or to concrete surface during installation shall not be permitted.

4. A relative installation tolerance between adjacent top of shim bearing surfaces of 1/16 inch will be allowed.

5. The Contractor shall submit a set of instructions, approved by the manufacturer, for installation and replacement of the fasteners in-track. The instructions shall describe the proper method of assembly and installation that shall be followed by the installer to ensure optimum performance and longevity of service. The component assembly and installation specifications and instructions provided in the installation requirements shall be in total agreement with the approved

fastener as-built drawings and the installation conditions used for the fastener assembly qualification testing on the concrete test block. As a minimum, the installation instructions shall include the following.

a. Installation procedures

b. Installation drawings

c. Anchorage insert care and installation

d. Shim thickness and placement restrictions

e. Lateral adjustment method

f. Anchor bolt torquing requirements

g. Allowable tolerances

h. Installation tools required

i. Installation requirements at bonded insulated joints

j. Installation requirements at rail joints

I. General

1. All fastener components shall comply with the minimum standards set forth herein.

2. All surfaces of materials shall be free of gaps, burrs, sharp edges, wrinkles, waves, blemishes, or other unsightly or unsafe defects that detract from a neat appearance of the finished product.

J. Metal Components

1. The metal top and base elements shall each be one-piece rolled, forged or cast steel or ductile iron.

2. The rail seat and clip mating surfaces of the top element shall be smooth, free from injurious warp and other imperfections in surface and projecting fins of metal caused during forming.

3. Ductile iron castings shall be minimally Grade 65-45-12 in accordance with ASTM A536. The chemical composition shall meet the acceptable level per SAE J434. The Brinell hardness in accordance with ASTM E10 shall be within the limits set by SAE J434. The microstructure shall be within the limits set by SAE J434. The fracture energy at 21.1 degrees Celsius in accordance with ASTM E23 shall be equal to or greater than three foot-pounds.

4. Rolled steel plate shall be minimally ASTM A36/A36M steel. The fracture energy at 21.1 degrees Celsius in accordance with ASTM E23 shall be greater than 15 foot-pounds.

K. Elastomer

1. The elastomer shall be natural rubber based as defined in ASTM D1566 and herein. Natural rubber based elastomer shall be defined as being 100 percent natural rubber or a blend with over 50 percent natural rubber. The manufacturer shall formulate the elastomer based on successful long-term case histories in similar service conditions to the BART System.

2. Except as required to meet the requirements for identification markings, exposed elastomer surfaces of the finished fastener shall be smooth with a finish and appearance equal to or better than an F-3 designation in accordance with RMA Rubbers Handbook.

3. The Durometer A hardness shall be between 40 and 70 as measured in accordance with ASTM D2240.

L. Anchor Bolts

1. The anchor bolts shall be 7/8-9 UNC heavy hex structural bolts of the following material in accordance with ASME B18.2.1.

   a. ASTM F3125/F3125M, Type 1, zinc coated, or

   b. SAE J429, Grade 5, zinc coated.

2. The threads shall be the Unified Coarse Thread Series with a Class 2A tolerance in accordance with ASME B1.1 and ASME B1.3.

3. The length shall be sufficient to provide at least one and a half inch thread engagement with the anchorage insert threads when the fastener is installed at the maximum vertical adjustment, using 1 inch of shims.

M. The washers shall be seven eighths inch diameter of the following material.

1. Hardened steel washers in accordance with ASTM F436/F436M. Carbon steel washers shall be zinc coated. Weathering steel washers shall be supplied for use with ASTM F3125/F3125M, Type 3 bolts.

2. Plain washers in accordance with ASME B18.21.1, Type B, regular, zinc coated.

3. Lock washers in accordance with ASME B18.21.1, helical spring, extra duty, zinc coated.

N. Anchorage Inserts

1. Anchorage inserts shall be nonwelded, female type, and shaped as required to prevent rotation and pullout. The total length shall not exceed five and a half inches. The insert shall remain within the envelope indicated on Figure 1 in all positions of adjustment.

2. The inserts shall be threaded to receive the anchor bolts using 7/8-9 UNC-2B threads in accordance with ASME B1.1. For anchorage inserts to receive zinc coated bolts, the pitch diameter shall be increased to account for the zinc coating thickness. The allowance for the pitch diameter shall be six times the minimum zinc coating thickness specified. The threads shall be coated with a rust inhibitive to prevent rust formation during preinstallation storage yet which will not hinder the threading on and tightening to proper torque of the anchor bolts during installation in track. The rust inhibitive shall be indicated and specified on Shop Drawings for approval by the Engineer.

3. The top of the insert in the installed position shall have a smooth and flat bearing surface. The bearing surface shall have a minimum area of one square inch.

4. A nylon or plastic pull-away type plug capable of sealing the insert threads against concrete seepage that is easily removable shall be provided with each insert.

5. The insert shall be made of one of the following materials.

    a. SAE J429, Grade 5 steel.

    b. Carbon steel with 0.50 percent maximum carbon and hardness in the range of 248-352 BHN (or 24-38 HRC).

    c. Ductile cast iron, Grade 65-45-12, in accordance with ASTM A536.

6. All inserts shall be coated with a fusion bonded epoxy. The fusion bonded epoxy coating shall be Scotchkote 206N, as manufactured by 3M Company; Scotchkote 134, as manufactured by 3M Company; Nap-Gard 7-2500, as manufactured by O’Brien Corporation; or equal.

7. The fusion bonded epoxy coating shall be applied to all surfaces of the insert, except for the threaded “hole” which must remain uncoated. The coating shall be applied in accordance with ASTM A775/A775M, except for the following modifications.

    a. The coating shall be applied by either the electrostatic spray method or the fluidized bed method, as recommended by the epoxy manufacturer.

    b. Prior to surface preparation, oil and grease shall be removed by solvent cleaning, vapor degreasing, or steam cleaning in accordance with SSPC-SP 1.

    c. The fusion bonded epoxy coating shall be applied in accordance with the coating manufacturer’s latest published instructions.

    d. The dry film thickness shall be 12 mils minimum to 30 mils maximum. The thickness shall be measured with a magnetic thickness gage.

    e. The coating shall be uniform and free of runs, sags, or chips. The coating shall meet the discontinuity (holiday) test requirements herein.

    f. The bend test specified in ASTM A775/A775M is not required.

O. Polyethylene Pads/Shims

1. Polyethylene shims shall conform to ASTM D1248, Type III, Class C, Grade W8 for high-density polyethylene plastic with a durometer hardness of 60 to 65D. The hardness shall be stable between plus 140 degrees Fahrenheit and minus 40 degrees Fahrenheit.

2. The nominal thickness of the pad shall be three eighths of an inch. The Contractor may vary pad thickness from a minimum of an eighth of an inch to a maximum of one half inch in one sixteenth inch increments. Test shims shall be three eighths of an inch thick.

3. The shims shall provide a half inch projection beyond the sides of the fastener perpendicular to the rail and a one inch projection beyond the sides of the fastener parallel to the rail. Anchor bolt holes in the shim shall be located at each bolt location. The hole shall be one inch in diameter.

4. The shims shall be used for qualification and production quality control tests and delivered to the Engineer after the testing is complete.

P. The following coating shall be used for metal components when specified.

1. Hot dip galvanizing in accordance with ASTM A153/A153M.

2. Mechanical zinc galvanizing in accordance with ASTM B695, Class 55-110.

2.04 GENERAL PRODUCTION

A. Production of direct fixation fasteners or components prior to the Engineer’s review and approval is prohibited.

B. Manufacture all direct fixation fasteners using the same methods used to produce qualification test pieces.

2.05 SOURCE QUALITY CONTROL

A. Production quality control inspection and testing shall be as specified herein.

B. Production Testing

1. Production quality control tests shall be performed during fastener manufacture to verify that the fasteners meet the requirements of these Specifications.

2. Perform all inspections and tests in accordance with the approved test program plan.

C. Elastomer Production Testing

1. The Contractor shall require the manufacturer to perform all inspections and tests specified herein on each of two samples certified to have been taken from the first production size batch of elastomer used in the manufacture of the initial

fastener production lot of 50 or more fasteners and having an equivalent degree of cure to the fastener elastomer. Use a separate pair of samples for each test. The elastomer batch shall meet the acceptance criteria for all the elastomer tests as specified herein.

2. After the first production size batch, the manufacturer shall perform the inspections and tests specified below on each of two samples certified to have been taken from the elastomer batch used in the manufacture of each fastener production lot and having an equivalent degree of cure to the fastener elastomer. Use a separate pair of samples for each test. The elastomer batch shall meet the acceptance criteria for the following tests as specified in herein.

    a. Hardness Test

    b. Tensile Strength and Ultimate Elongation Tests

    c. Tear Resistance Test

    d. Rheology (Cure and Strength Indicator) Test

    e. Specific Gravity Test

3. Should any elastomer sample fail to meet the test requirements, the entire elastomer batch shall be rejected and the entire fastener production lot manufactured from the rejected elastomer batch shall also be rejected.

4. Should an elastomer batch be rejected, the manufacturer shall perform all tests and inspections specified herein on each of two samples certified to have been taken from the next production size batch of elastomer used in the manufacture of fasteners and having an equivalent degree of cure to the fastener elastomer. Use a separate pair of samples for each test. The elastomer batch shall meet the acceptance criteria for all the elastomer tests as specified herein.

D. Anchorage Assemblies Production Testing

1. Test Method

    a. A discontinuity (holiday) test shall be performed on each anchorage insert produced, in accordance with NACE S0188, at the fusion bonded epoxy applicator’s plant using a high voltage holiday detector at 2 kV. The test shall be performed with a brass brush on the stem.

    b. As an alternative a discontinuity (holiday) test shall be performed on each anchorage insert produced using a low voltage holiday detector at 9 V to 100 V dc. The test shall be performed using an electrolyte solution.

2. Any piece having holidays shall be rejected; however, repair of one minor holiday per insert shall be permitted. Repaired inserts shall be retested as specified above, and the repaired insert shall be free of holidays upon repair. Any repaired inserts that fail the retest shall be rejected. An insert shall be repaired and retested only once. Any repaired inserts that fail the retest may be stripped of all coating, recoated as specified herein and retested as specified herein. The repair method shall conform to ASTM A775/A775M. The Contractor shall submit the proposed repair method with the test procedure for approval by the Engineer.

E. Fastener Production Testing

1. Production quality control testing of fasteners shall be performed on two fasteners from the first 50 fasteners produced and on two fasteners from each production lot. A production lot is defined as a quantity of manufactured and completed fasteners produced in a continuous run, but not to exceed 5,000 units. Fasteners shall be selected for testing by the Engineer.

2. All production quality control tests for each particular production lot shall be successfully completed and the test reports for the tests approved by the Engineer before that production lot will be accepted. Should either fastener fail to meet the test requirements, two additional fasteners from the same production lot shall be subjected to the complete set of production quality control tests. If either of the second pair of tested fasteners fails to meet the test requirements, the entire production lot shall be rejected or tested and only those fasteners that successfully pass the production quality control tests will be accepted. The cost of all such additional testing, including costs for the Engineer or a representative of the Engineer to witness the tests, of any fastener or fastener component that does not comply with these Specifications shall be at the Contractor's expense.

3. Fasteners used for production testing and meeting all test requirements shall be permanently marked as production test fasteners and shall be delivered separately to the Engineer.

4. Production quality control testing of fastener assemblies shall include the following tests as specified herein

   a. Vertical Load Test

   b. Vertical Uplift Test

   c. Lateral Load Test

   d. Lateral Restraint Test

   e. Longitudinal Restraint Test

   f. Electrical Resistance and Impedance Test

5. Contractor shall certify that all fasteners were manufactured in the same manner as the fasteners subjected to the Qualification Testing. Upon submittal of certification, the entire lot of fasteners will be released by the Engineer for shipment.

PART 3 – EXECUTION

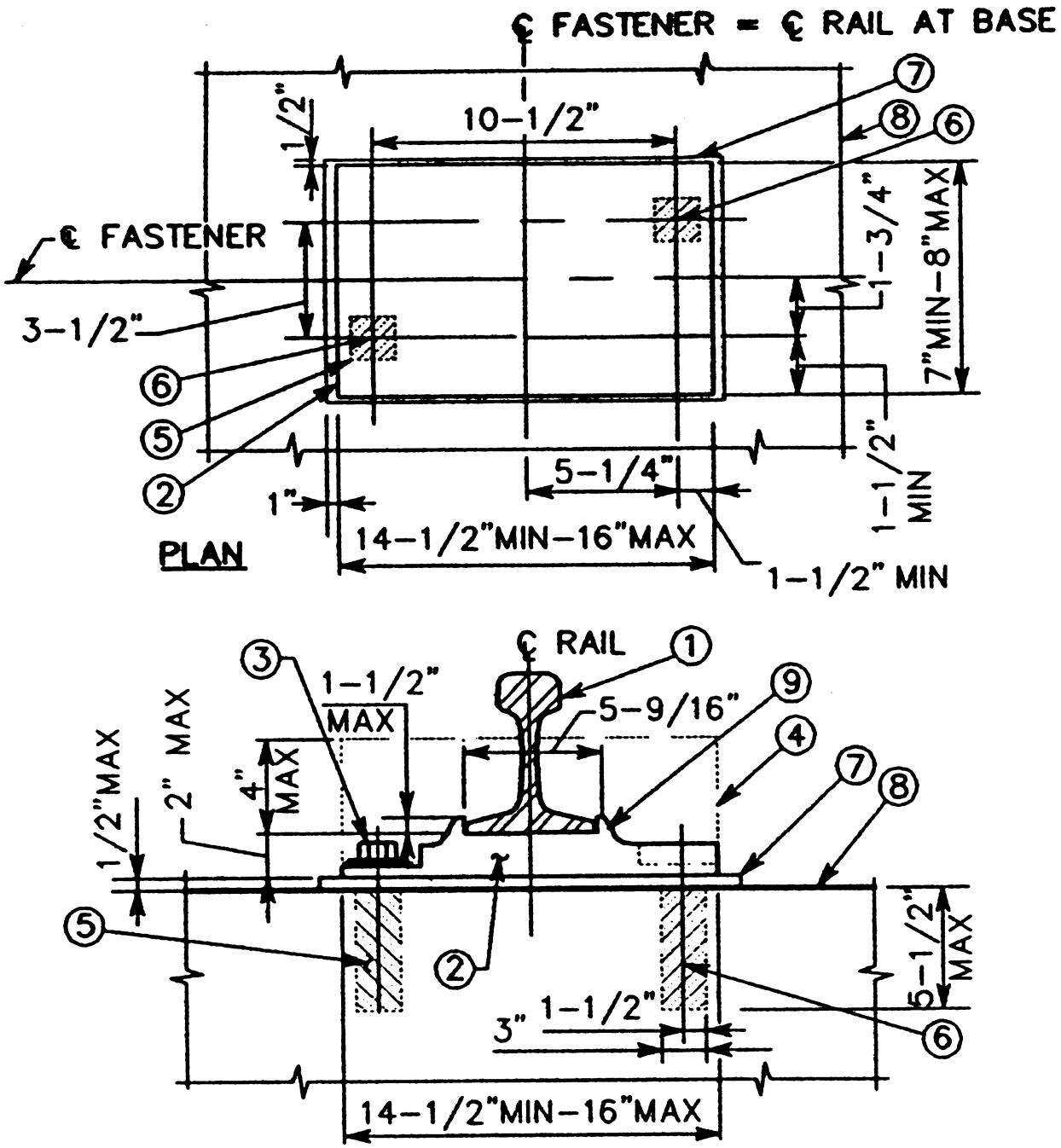
3.01 INSTALLATION

A. Install direct fixation fasteners in accordance with the respective manufacturer's recommended installation instructions and procedures and as provided, except as modified herein.

B. Install direct fixation fasteners in accordance with the requirements of Section 34 05 17, Common Work Results for Trackway.

END OF SECTION 34 11 37

ATTACHMENTS (FIGURES) FOLLOW



1. 119 RE RAIL
2. FASTENER BODY
3. 7/8” ANCHOR BOLT
4. FASTENER ENVELOPE
5. ANCHORAGE ENVELOPE
6. CENTER LINE - ANCHOR BOLT
7. SHIM
8. CONCRETE TRACK BED
9. SHOULDER

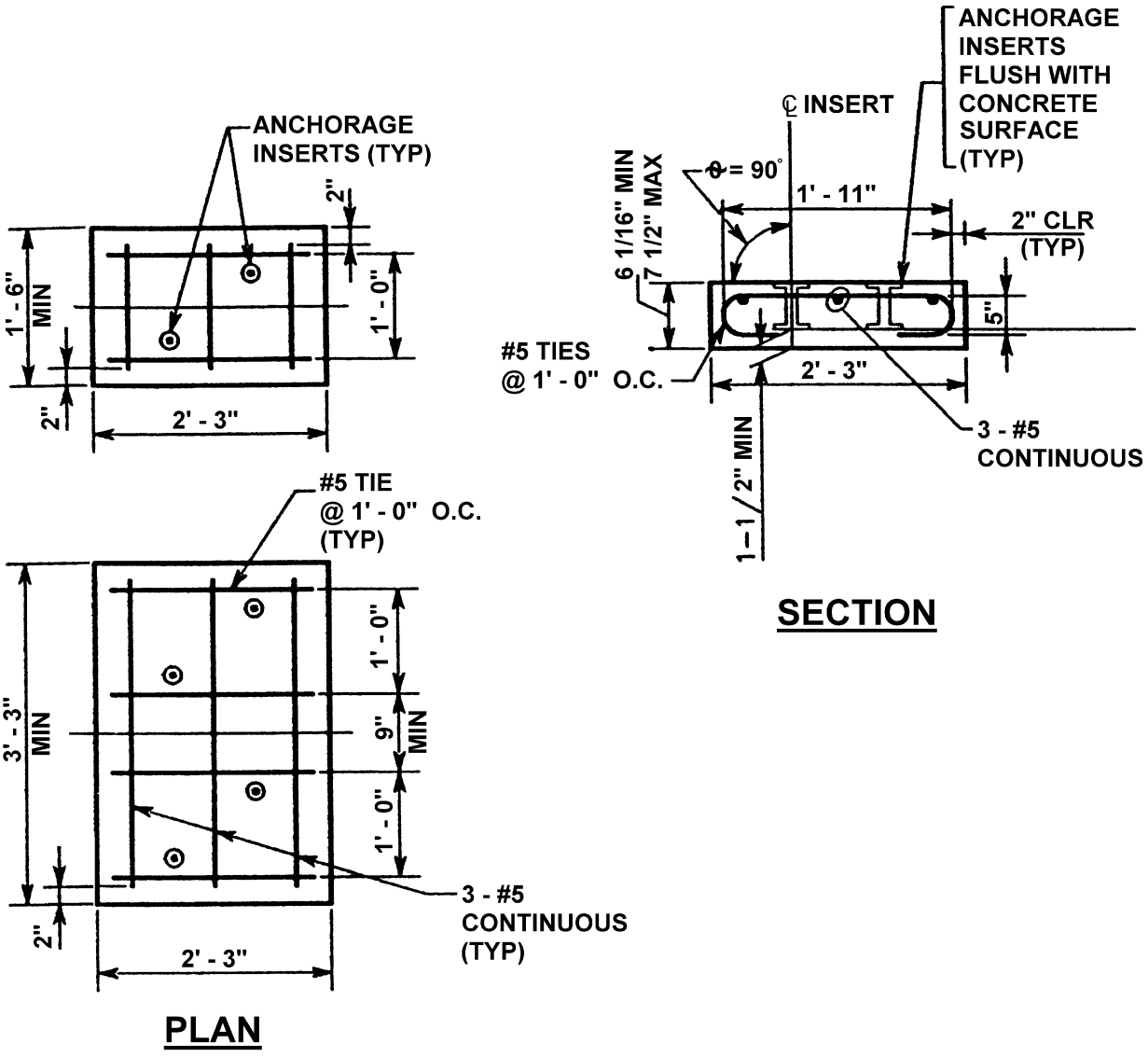


FIGURE 2 – DF CONCRETE TEST BLOCK

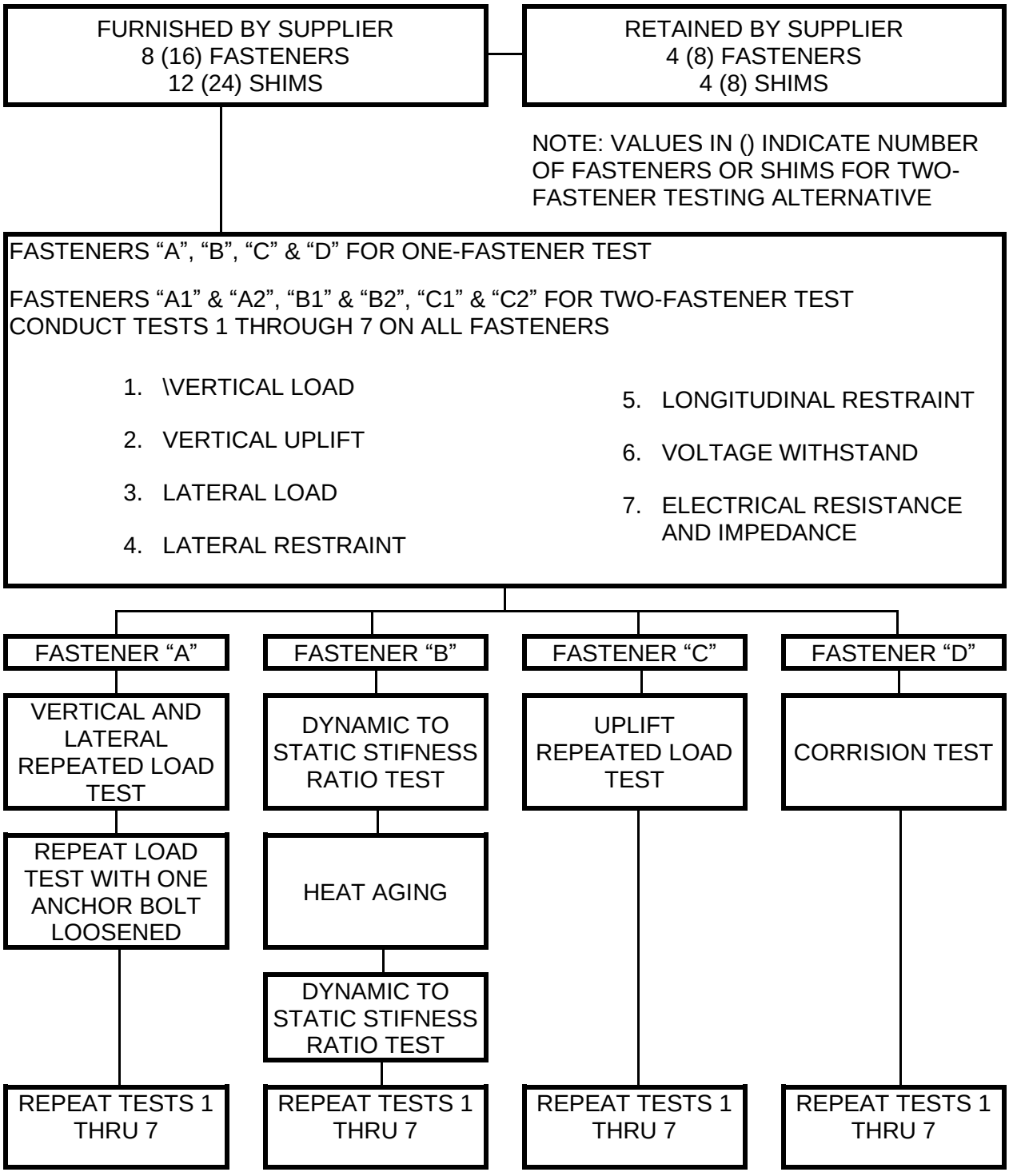
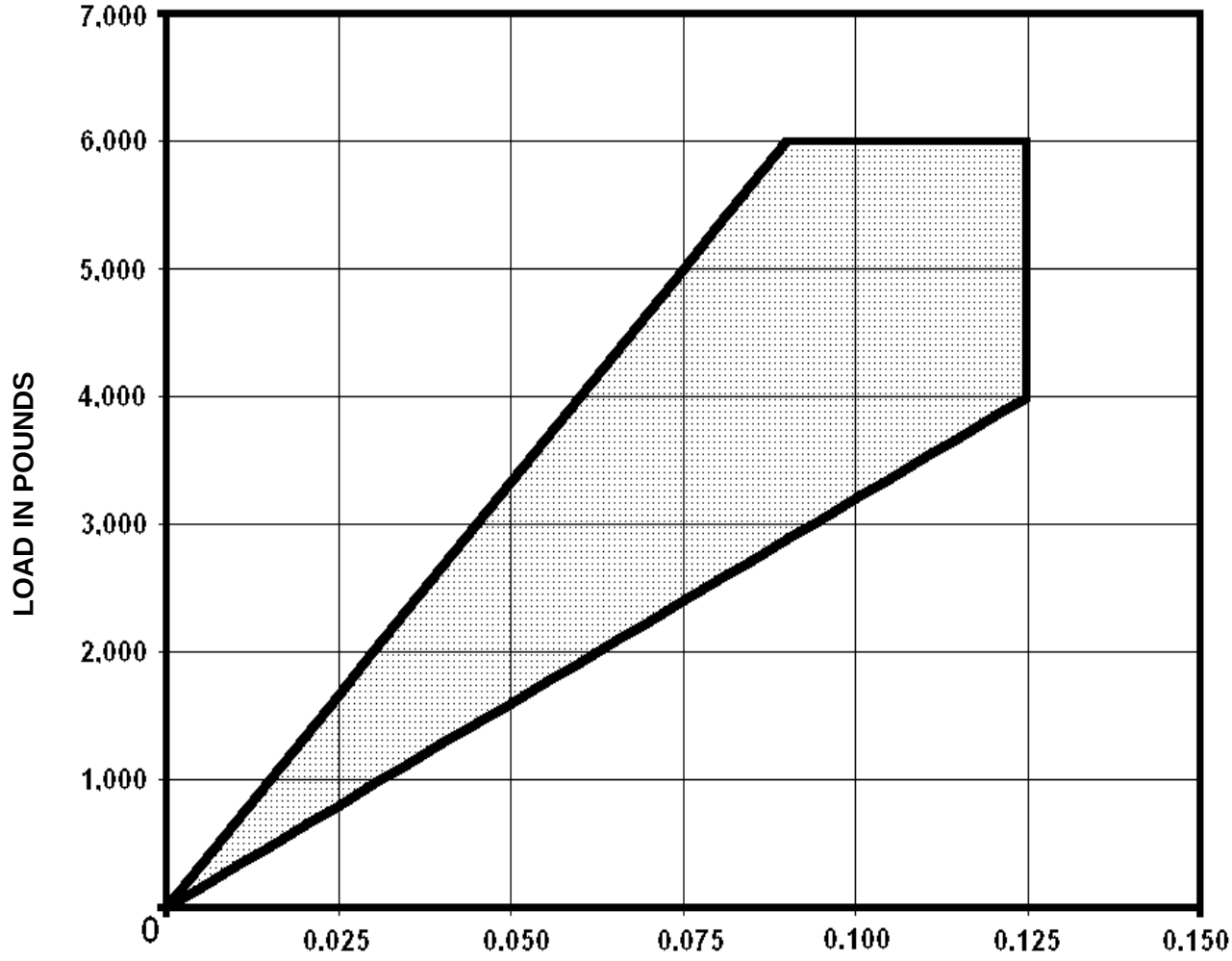


FIGURE 3 – FASTENER ASSEMBLIES QUALIFICATION TESTING SEQUENCE



ACCEPTANCE LOAD vs DEFLECTION ENVELOPE.
INDICATED SPRING RATES ARE ONLY FOR DEFINING ENVELOPE OUTLINE.

FIGURE 4 – LATERAL AND LONGITUDINAL RESTRAINT TEST ACCEPTANCE CRITERIA

END OF ATTACHMENTS (FIGURE)

SECTION 34 11 93

TRACK APPURTENANCES AND ACCESSORIES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Rail Fasteners.

B. Rail Lubricators.

C. Pedestrian, Cart and Road Crossings and Maintenance Accesses.

D. Bollards.

E. Track Bumpers.

F. Friction Buffers.

1.02 RELATED SECTIONS

A. Section 34 11 23, Special Trackwork

B. Section 34 11 24, Direct Fixation Track

C. Section 34 11 27, Ballasted Track

D. Section 34 11 30, Embedded Track

1.03 MEASUREMENT AND PAYMENT

A. Miscellaneous track materials will not be measured separately for payment. All costs in connection therewith will be considered as included in the applicable Contract lump sum or the Contract unit price per linear foot for trackwork of the different types indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM F3125/ F3125M — Standard for High Strength Structual Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi (830 MPa) and 150 ksi (1040 MPa) Minimum Tensile Strength, Inch and Metric Dimensions

2. ASTM D4956 — Standard Specification for Retroreflective Sheeting for Traffic Control

B. California Department of Transportation (Caltrans) Standard Specifications:

1. Section 39 Asphalt Concrete

1.05 SUBMITTALS

A. Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Refer to Section 34 05 17, Common Work Results for Trackway, for additional submittal requirements.

C. Submit shop and installation drawings of the rail lubrication for each location.

D. Provide additional submittals as required herein.

E. Certification of rail lubricator tests.

1.06 RAIL LUBRICATOR TESTING

A. All rail lubricator testing shall be performed with the aid of and entirely witnessed by a representative of the manufacturer.

B. Rail lubricators shall be tested as follows, after 10 train passes, lubricant is present on the gage side of the rail, but not on the top of the rail two hundred feet away from the lubricator location.

1. Rail lubricators shall be as full as possible with lubricant before commencement of testing.

2. Rail lubricators shall be as full as possible with lubricant immediately after completion of testing.

C. The rail shall be cleaned free of all grease, by the Contractor, prior to the beginning of any testing.

D. Upon completion of successful testing the rail shall be cleaned free of all grease, and the lubricator turned off.

E. The Contractor shall provide written certification upon completion of testing. A separate certification shall be provided for each rail lubricator and shall be signed by the manufacturer’s representative.

PART 2 – PRODUCTS

2.01 DISTRICT-FURNISHED MATERIALS

A. Refer to Section 01 64 13, District-Furnished Materials and Equipment, of the Contract Specifications for description and quantity of District-furnished materials.

2.02 CONTRACTOR-FURNISHED MATERIALS

A. All products, tools, materials, equipment, and labor required to complete all aspects of the work shall be furnished by the Contractor.

2.03 RAIL FASTENERS

A. District's rail fastener systems are “Designated Matching Products” (DMP) as specified in the Contract Specifications. The system includes clips and where required shoulders, tie pads, and insulators as indicated in the Contract Drawings.

1. Clips shall be forged from alloy steel and quenched to achieve a longitudinal restraint of 2,400 pounds per rail seat. Except at rail joints, as provided for herein, only right-handed rail clips shall be used.

2. The same standard rail clip shall be used in all positions of adjustment.

3. The same insulators shall be used on the field and gage side.

B. Special Rail Clips at Rail Joints

1. Special rail clips shall be used for rail joints and insulated rail joints; right-handed clips shall be used wherever possible; either right or left-handed clips may be used.

2. At insulated rail joints, the rail clips shall not come in contact with any portion of the rail joint, thus helping ensure the integrity of the insulation capability of the joint.

3. Contractor altered rail clips will not be accepted.

C. Rail Seat Design for concrete and resilient ties shall be as indicated in the Standard Drawings incorporated in the Contract Documents.

D. Direct Fixation Fasteners:

1. The rail clips shall be designed to be easily installed and removed by one person with standard, readily available hand tools, but not able to vibrate loose under load. Clip installation and removal shall not damage the fastener body, clip holder, clip, or rail. The rail clip shall not notch nor otherwise damage the rail base during installation or removal.

2. The rail clips shall be held to the metal top element by a shoulder aligned with the rail base.

3. Neither the rail clip nor the clip shoulder shall make point contact with the rail. The rail clip contact area with the rail shall not be shorter than one inch measured along the rail and not smaller than five thirty seconds of a square inch in area.

4. The clip action in track shall be such that longitudinal rail slippage can occur without denting, carving, or scoring the rail flange and without permanently stressing, bending, twisting, or otherwise damaging the clips, or clip shoulders.

5. The fasteners shall have either stops or visible permanent marks to indicate the proper position to which the spring clips are to be inserted.

6. The fastener shall permit removal of the rail clips so that the rail may be removed by lifting it vertically until it is completely free of the fastener without disturbing the horizontal and vertical alignment of the fastener.

7. The modal frequencies of the spring clip and the metal top element shall be different by such a factor that the spring clip will not vibrate loose from the metal top element.

8. The rail clips shall be held by a clip holder that does not allow lateral rail adjustment on the metal top element.

9. The clip holder shall be a permanent and integral part of the metal top element.

10. The rail clip assembly shall not include any elastomeric components.

11. Direct fixation fasteners shall have two spring rail clips, one on each side of each rail, for securing the running rail to the metal top element of the fastener body.

12. Special Trackwork Direct Fixation Fasteners

    a. Rail clip assemblies for special trackwork rail fasteners may vary from as many as one rail clip assembly on each side of the rail base, or a rail clip assembly opposite an adjustable rail brace, or two opposing adjustable rail braces.

    b. Where rails converge and there is insufficient space between rails for a clip assembly, a bolted clip may be used. Where there is insufficient space for a rail clip assembly, rail stop may be used. In any case there shall be no more than two consecutive fasteners without a rail clip assembly or rail clip.

E. Rail Insulators shall be as indicated in the Standard Drawings.

F. Rail Bearing Pads shall be used beneath the base of the rail on all concrete ties and resilient ties and shall be as indicated in the Standard Drawings.

G. Embedded shoulders shall be ductile cast iron.

2.04 TURNOUT PLATE ANCHORAGE ASSEMBLIES

A. All ties of the same length shall be identical except for the addition of conduits and as follows:

1. Ties supporting switch machines for all turnouts types and derail layouts may be different than ties of the same length used at other locations; however, these ties shall all be identical and work for all switch types, layouts and types of switch machines.

2. Ties supporting auxiliary throwing device may differ from other ties of the same length only by the addition of the anchorage assemblies required for the auxiliary throwing device.

B. A single insulating pad shall be provided under each special plate. Pads shall be the same type and thickness and shall extend at least a half inch beyond the sides and end of the plate.

C. The design of special plates on concrete special trackwork ties shall also include the following:

D. Turnout plates shall be secured to the tie with a minimum of two anchorage assemblies, one on each end of the plate.

E. Each anchorage assembly shall consist of a cast in shoulder, insulator, and clip of the same type used for concrete ties.

2.05 INSTALLATION

A. Installation, removal and maintenance of all fasteners, fastener bodies, plates or any component, in all positions of adjustment shall be accomplished without encroachment into the restricted area shown in Figure 1.

2.06 REQUIRED TESTING

A. The various tests required for rail fasteners are not intended to test the DMP rail fastener, but rather to test that they function properly with the devices supplied by the Contractor and that the proper fastening materials are supplied.

B. Waivers of any required tests based upon previous acceptance by the District, will not be permitted, except as specifically provided herein.

2.07 RAIL LUBRICATORS

A. Rail lubricators shall be installed at locations indicated on the Contract Drawings.

B. Manufacturer’s standard model and standard accessories shall be provided, except as modified herein.

C. Manufacturer’s standard model and accessories shall be in current use on the BART system or on other transit systems similar to BART.

D. Rail lubricators’ installation locations shall be equipped with a 10 A/120 V electrical outlet and floodlight with timer switch.

E. Rail lubricators shall be the same manufacturer, type and model throughout.

F. Adjustable metering of grease.

1. Metering of grease shall be adjustable by wheel pass, and,

2. Metering of grease shall be adjustable by volume.

G. Electric gear pump controlled by electric signals from a magnetic wheel detector, including all equipment required for both bi-directional and omni-directional controls.

H. No rail grinding or drilling shall be required to install the wiping bars.

I. Remote “clean hands” grease tank, allowing full maintenance on the pump and mechanisms outside of the grease tank.

J. Provide four single port wiper bars, per track, two each rail.

K. Lubricant used in the rail lubricators will be provided to the Contractor by the Engineer.

2.08 PEDESTRIAN, CART, AND ROAD CROSSINGS AND MAINTENANCE ACCESSES

A. Install pedestrian, cart, and road crossings and maintenance accesses at locations indicated on the Contract Drawings.

B. On all ballasted mainline, spur, and transfer tracks, the design shall be a full depth panel system. The same panel design, size, length and type shall be used throughout.

C. On all direct fixation mainline, spur, and transfer tracks, the design shall be a full depth panel system. The same panel design, size, length and type shall be used throughout.

D. On all yard tracks, the design shall be full depth asphalt concrete paving with continuous rubber flangeway fillers.

E. Requirements:

1. Five foot six inch track gage.

2. 119 RE Rail.

3. No direct fixation to ties or concrete.

4. Flangeway dimensions shall be two and a half inches in depth and width.

5. Skid resistant surface.

6. Positive end restraint.

7. 45-degree sloping at end sections.

8. Adaptable for skew crossing and installation on curves.

9. Installable without modification to tie or direct fixation pad spacing, track materials or configuration.

10. Shall provide high dielectric strength when wet with salt water, and shall not interfere with the District's train control or third rail propulsion systems.

F. Concrete Panels

1. Concrete panels and hardware shall conform to Section 03 40 00, Precast Concrete.

2. Concrete panels shall have lifting swivels with a manufacturer-recommended safe working load capacity of 4,500 pounds.

3. Provide continuous plain elastomer type bearing pads, integral to the crossing panels, conforming to Section 03 15 15, Elastomeric Bearing Pads.

4. Provide rubber flangeway fillers, integral to the crossing panel manufacturer's standard design.

G. Asphaltic Concrete Paved Road and Pedestrian Crossings

1. Asphaltic Concrete Crossings shall only be used on ballasted track within yards and local control areas, as indicated. The asphaltic paving shall be full depth, without base course and in accordance with Section 32 12 16, Asphalt Paving.

2. The installation shall conform to the following requirements.

   a. Full depth rubber flangeways.

   b. 30-degree slope on end sections.

   c. No cold joints.

   d. Before placing asphalt concrete, a tack coat (paint binder) shall be applied to all surfaces against which asphalt concrete surfacing will be placed. Tack coat shall be applied in accordance with Section 39 of the Caltrans Standard Specifications at the rate of from 0.05 to 0.10 gallon per square yard.

   e. The rubber flangeway material shall be tight and uniform against the running rail with no gaps greater than one sixteenth inch and shall extend between three and six inches beyond the adjacent paving.

2.09 BOLLARDS

A. Bollards shall consist of a concrete-filled steel pipe with a concrete foundation.

B. Provide 6 inch, Schedule 40, galvanized steel pipe conforming to the requirements of Section 05 50 00, Metal Fabrications.

C. Bollards shall extend between 44 and 48 inches above the nearest running rail.

D. Concrete shall comply with applicable requirements of Section 03 05 15, Portland Cement Concrete. Concrete shall be Class 3000 with three fourths inch maximum aggregate size.

E. Three one inch wide stripes, spaced six inches apart, with the first stripe as near as possible to the top of the bollard shall be applied.

F. Reflective tape shall conform to ASTM D4956, Type I, Class 1.

2.10 TRACK BUMPERS

A. General: The track bumper shall be designed for installation at the end of track (end of line) to bring a vehicle to a controlled stop without damage to any car of the BART train.

B. Site: Track bumper shall be designed for the BART system including its track gage (66 inches) and rail type (119 RE continuous welded rail) and the following requirements:

1. Slope: 0.00 percent. Preferred, but shall be applicable to track on grade.
2. Ballasted track: Concrete Cross Ties at 30 inches spacing.
3. Resilient ties or DF track: fastener spacing varies; 24 inch–30 inch

C. Design Criteria:

1. Manufacturer's standard model and accessories shall be in current use on the BART system or on other transit systems similar to BART.
2. The anti-climber adapter height and detail shall be compatible with the BART vehicle
3. Fixed head.
4. Bolted connection to rail.

2.11 FRICTION BUFFERS

A. General: The friction buffer shall be designed for installation at the end of tracks (end of line) in ballasted track area to bring an empty non-accelerating 10-car BART train to a controlled stop without damage to any cars of the BART train.

B. Site: Friction buffers shall be designed for the BART system including its track gage (66 inches) and rail type (119 RE continuous welded rail) and the following requirements:

1. Slope: 0.00 percent

2. Ballasted track: Concrete Cross Ties at 30 inches spacing

C. Design Criteria:

1. Manufacturer’s standard model and accessories shall be in current use on the BART system or on other transit systems similar to BART.

2. Impact speed: 10 miles per hour.

3. Average deceleration over the stopping distance shall not exceed 0.114 g.

4. Shall have hydraulic ram to absorb slow speed impacts of three miles per hour mph.

5. The anti-climber adapter height and detail shall be compatible with the BART vehicle.

2.12 GENERAL PRODUCTION

A. Production of miscellaneous track materials or components prior to the Engineer's review and approval is prohibited.

B. Manufacture all miscellaneous track materials using the same methods used to produce qualification test pieces.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install miscellaneous track materials in accordance with the respective manufacturer's recommended installation instructions and procedures and as provided, except as modified herein.

B. Install miscellaneous track materials in accordance with the requirements of Section 34 05 17, Common Work Results for Trackway.

3.02 BOLLARDS

A. Provide bollards to protect the ends of third rail sections at pedestrian, cart and road crossings and maintenance accesses and as indicated.

END OF SECTION 34 11 93

ATTACHMENT FOLLOWS

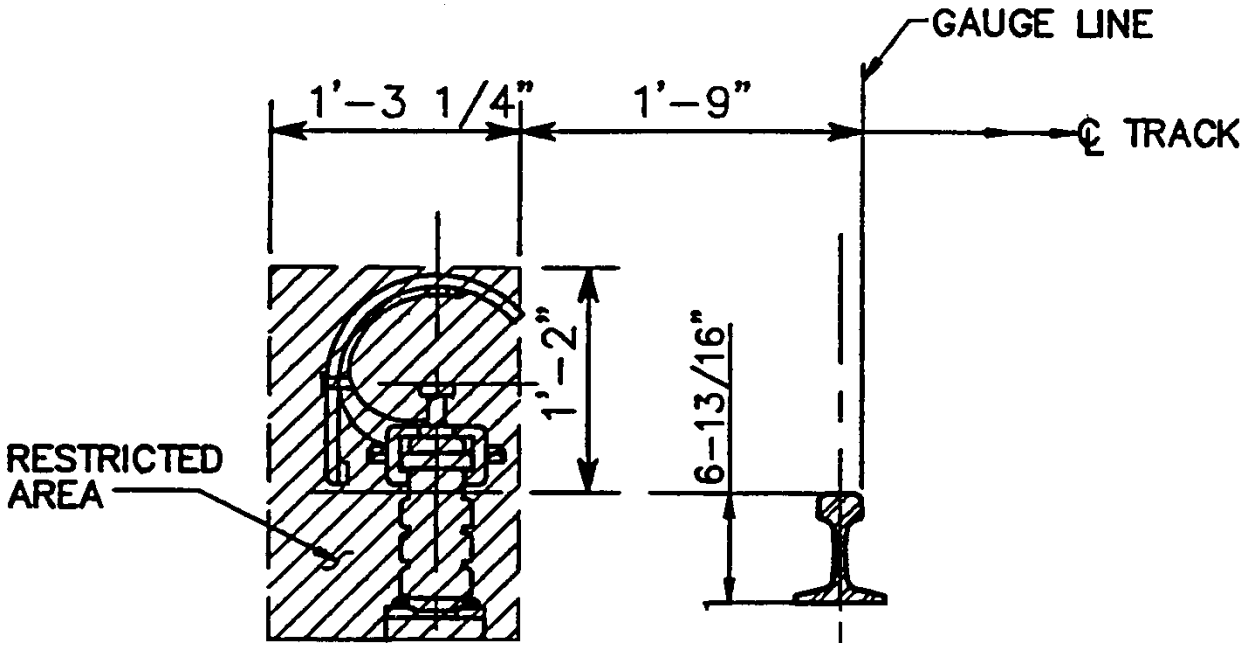


FIGURE 1
RESTRICTED AREA DURING FASTENER INSTALLATION AND MAINTENANCE

END OF ATTACHMENT

SECTION 34 21 01

GENERAL REQUIREMENTS FOR THE TRACTION POWER SYSTEM

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. This Section includes the general requirements for the provision of all electrical equipment, cabling, conduit/cable tray, underground structures and ductbanks, cable trenches, materials, and appurtenances for a complete and operable Traction Power System.

1.02 RELATED SECTIONS

A. Refer to the following Sections for requirements:

1. Section 01 11 00 Summary of Work
2. Section 01 31 19 Project Meetings
3. Section 01 32 16 Construction Progress Schedules
4. Section 01 33 00 Submittal Procedures
5. Section 01 33 23 Shop Drawings, Product Data and Samples
6. Section 01 35 14 Operating System Interface
7. Section 01 35 24 Construction Safety
8. Section 01 35 33 Security Procedures
9. Section 01 42 19 Reference Standards
10. Section 01 43 00 Quality Assurance
11. Section 01 45 00 Quality Control
12. Section 01 74 14 Cleaning
13. Section 01 77 00 Closeout Procedures
14. Section 01 78 39 Contract Record Documents
15. Section 26 05 53 Identification Requirements
16. Section 34 21 05 Prefabricated AC and DC Equipment Houses and Related Equipment
17. Section 34 21 11 Multi-Function Protection Relay Equipment

18. Section 34 21 17 AC Switchgear (SF 6 Gas Insulated Type)
19. Section 34 21 18 AC Switchgear (Sealed Vacuum Type)
20. Section 34 21 19 Separable Insulated Connectors
21. Section 34 21 20 AC Busways
22. Section 34 21 21 Transformer-Rectifier Units
23. Section 34 21 25 DC Switchgear
24. Section 34 21 27 Liquid Immersed Type Auxiliary Power Transformers
25. Section 34 21 30 Negative Grounding Device
26. Section 34 21 33 Traction Power Control, Monitoring and Display Panel
27. Section 34 21 35 Emergency and Transfer Trip System
28. Section 34 21 40 DC Control Power System
29. Section 34 21 50 Common Materials and Methods for Traction Power
30. Section 34 21 55 DC Manual Disconnect Switch
31. Section 34 21 56 MV Isolation Disconnect Switches
32. Section 34 21 60 Grounding and Bonding for Traction Power Facilities
33. Section 34 21 70 Traction Power Facilities Installation Requirements
34. Section 34 21 75 Traction Power System Level Factory Testing
35. Section 34 21 80 Traction Power System Field Acceptance and Testing Requirements
36. Section 34 22 23 Traction Power Cables
37. Section 34 24 13 Contact Rail System

1.03 MEASUREMENT AND PAYMENT

A. Separate measurement or payment will not be made for work required under this Section. All costs in connection with the work specified herein will be included with related items of Work in the Bid Schedule of the Bid Form, or incidental to the Work.

1.04 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples for submittal requirements and procedures.

B. Safety Equipment as specified in Section 1.07D.8 herein.

C. FMECA Plan as specified in Section 1.10D herein.

D. FMECA Report as specified in Section 1.10D herein.

E. Product Data: Submit product data as specified in Section 1.16D.1 herein.

F. Product Shop Drawings as specified in Section 1.16D.2 herein.

G. Site Specific Design Package as specified in Section 1.16D.3 herein.

H. Calculations as specified in Section 1.16D.4 herein.

I. Studies as specified in Section 1.16D.5 herein.

J. Traction Power Cables and LV Equipment as specified in Section 1.16E.1 herein.

K. Professional Architectural/Engineering Design as specified in Section 1.16F.1 and 2 herein.

L. Closeout Procedures as specified in Section 1.16G1 and 2 herein.

M. Asset Management as specified in Section 1.17A and B herein.

N. Closeout Submittals as specified in Section 1.23 herein.

O. Maintenance Manual as specified in Section 1.24 herein.

P. Training Instructor Qualifications and Experience as specified in Section 3.01B herein.

Q. Training Program Plan, the Instructor’s Guides and Attachments, Student Training Materials, Staged Training Program as specified in Section 3.01C herein.

R. Final Training Deliverables as specified in Section 3.01.I.2 herein.

1.05 REFERENCES

A. The Traction Power System shall be designed, fabricated, constructed and tested in accordance with the latest edition of the following codes, standards, and specifications except as provided otherwise herein and elsewhere in the Contract. Where requirements conflict with requirements specified herein the more restrictive requirements shall apply.

B. American National Standards Institute (ANSI):

1.	ANSI C2	National Electrical Safety Code
2.	ANSI Z55.1	Gray Finishes for Industrial Apparatus and Equipment

C. California Code of Regulations:

1.	Title 24, Part 3	California Electrical Code

D. Institute of Electrical and Electronics Engineers (IEEE):

1.	IEEE 1653.2	Uncontrolled Traction Power Rectifiers for Substation Applications Up to 1,500 V DC Nominal Output
2.	IEEE 693	Recommended Practice for Seismic Design of Substations

E. Military Specifications:

1.	MIL-STD-1629A	Procedure for Performing a Failure Mode Effect and Criticality Analysis

F. National Fire Protection Agency (NFPA):

1.	NFPA 70	National Electrical Code
2.	NFPA 130	Fixed Guideway Transit Systems and Passenger Rail Systems

1.06 TRACTION POWER SYSTEM DESCRIPTION

A. The Traction Power System comprise of the following subsystems: high voltage substations; 34.5 kV 3-phase AC sub-transmission system; traction power facilities; 1,000 Volt DC distribution system; and protection, metering, control, and monitoring.

B. The high voltage substations serve as the receiving point for high voltage power from the local electric utility service provider. These substations are comprised of power transformers and switching equipment to step down the high voltage power to 34.5 kV 3-phase AC for supply to the traction power substations via the switching stations and the 34.5 kV AC sub-transmission system.

C. The 34.5 kV sub-transmission system receives its 34.5 kV AC power from the high voltage substations via the switching stations. The system, consisting of two parallel 34.5 kV 3-phase AC cable circuits which are routed within the transit system right-of-way, transmits the 34.5 kV AC power to the traction power substations.

D. The traction power facilities include the switching stations, sectionalizing stations, traction power substations, and gap breaker stations. A site may incorporate a combination of these facilities.

E. The traction power substations convert the 34.5 kV, three-phase, AC power received from the 34.5 kV sub-transmission system to a nominal 1,000 V dc power positive and negative for distribution of positive power to the contact rail system or third rail and for negative return to the running rails.

F. Sectionalizing stations provide sectionalizing of the sub-transmission system. One sub-transmission section includes a high voltage substation and a switching station. During an emergency condition caused by the failure of the high voltage substation and/or switching station in a 34.5 kV sub-transmission section, the circuit breakers in the sectionalizing station are closed to transfer the load in the failed section to an adjacent healthy 34.5 kV sub-transmission section.

G. Switching stations receive the 34.5 kV AC 3-phase power from the high voltage substations for supply to the 34.5 kV AC 3-phase sub-transmission system.

H. Gap breaker stations provide switching and allow isolation of contact rail sections on the mainline, pocket tracks, crossovers, and turnouts.

I. The DC distribution system consists of the DC feeder cables, contact rail system, and the negative return cables that are connected to the running rails providing as return path for negative current back to the substations.

J. The Traction Power System equipment and facilities are designed for local and remote operation from the District's Operation Control Center (OCC) and the Yard Control Towers (YCT).

K. Traction power equipment is designed and equipped with protection devices to protect equipment and personnel against electrical faults and abnormal system conditions.

L. Metering devices are provided in key circuit locations for local and remote measurement and recording of electrical operating parameters.

1.07 QUALITY ASSURANCE, QUALITY CONTROL AND SUPPLIER QUALIFICATIONS

A. Refer to Section 01 43 00, Quality Assurance and Section 01 45 00, Quality Control for quality control, quality assurance and qualification requirements.

B. Electrical components, devices, and accessories shall be listed and labeled in conformance with NFPA 70, Article 100. Electrical components, devices, and accessories shall comply with NECA 1, Standard for Good Workmanship in Electrical Construction.

C. The Contract indicates preliminary dimensions for equipment, including clearances between equipment and for adjacent surfaces and other items. Deviations to indicated or noted dimensions shall be submitted to the District for review and approval.

D. The engineer of record, lead engineer, designers and the equipment vendor's engineer, for the design of the traction power facilities, must have documented past project-proven experience in the design, manufacture, delivery, testing and commissioning of traction power facilities for mass transit, and shall be subject to approval by the District.

E. The engineer from the rectifier transformer manufacturer organization, in charge of the design of the rectifier transformers, must have a minimum of five years of project-proven experience in the design of three-winding rectifier transformers.

F. The manufacturer of the Traction Power System's equipment and cables shall have a minimum of five years of successful and proven transit, industrial, or utility experience of providing equipment and cables like those furnished under the Contract.

G. The manufacturer of the rectifier transformer must have a minimum of five years manufacturing experience with three-winding, oil-filled and/or dry type rectifier transformers utilizing IEEE 1653.2 Circuit No. 31 configurations of the same voltage class as specified in Section 34 21 21, Transformer-Rectifier Units.

H. Equipment, devices, components, cabling, materials, and appurtenances shall be proven standard products, or equivalent to the standard products of manufacturers engaged in the production of such entities for at least the past five years.

I. Equipment, devices, components, cabling, materials, and appurtenances shall be designed to operate within the specified environmental conditions specified below.

J. All materials shall be new, unused in any other application, and shall possess properties and characteristics in accordance with the applicable industry standards. All equipment, including parts and devices, shall be new, the manufacturer's latest standard designs that conform to the Contract, and free from defects in material and workmanship.

K. Furnish at the time of Bid certifications of compliance concerning the experience records of the manufacturers, engineers, and electrical Subcontractors, substantiated with documented information and references; and product years-in-service data, as required.

L. Components of major equipment, such as relays, control switches and protective devices, do not have to meet the five-year experience requirement.

M. All prescribed equipment, materials, cables and appurtenances shall not only be designed and constructed to operate within the intended application and operating environment, but also have a proven track record of successful operation.

1.08 GENERAL FUNCTIONAL, OPERATIONAL, PERFORMANCE REQUIREMENTS

A. Safety Design

1. The Traction Power System design and operational procedures shall incorporate the following as a minimum:

a. Avoiding, eliminating, or reducing hazards identified by engineering analysis, design choices, material selection, or substitution.

b. Controlling and minimizing hazards (to personnel, the public, and to equipment and materials), which cannot be avoided or eliminated.

c. Incorporating fail-safe principles where failures would disable system components or cause human injury, damage to equipment, or inadvertent operation of the equipment. In case of equipment failure the system shall send out alarms and shut-down when unsafe conditions are present.

d. Locating equipment components so that access to them by the required personnel during operation, maintenance, repair, or adjustment shall not require exposure to hazards such as entrapment, chemical burns, electrical shock, cutting edges, sharp points, or toxic atmospheres.

e. In addition to equipment enclosure doors protective barriers/insulated covers limiting contact to energized terminals and/or buses shall be incorporated into the design of equipment.

f. Providing suitable warning and caution notes in operations, assembly, maintenance, and repair instructions; and easily visible distinctive markings on hazardous components, equipment, or facilities for personnel protection.

g. All components containing or generating obnoxious, flammable, and harmful gases shall be vented to the outside environment in compliance with NFPA, IEEE, EPA, and CALOSHA.

h. Cables and wires of different systems and high and low voltage conductors shall be physically segregated/separated from each other in accordance with the requirements specified in the NEC and CEC.

B. Security

1. Equipment enclosures and equipment houses shall have a District approved locking device.

2. Refer to the Contract for locking/security hardware and software requirements which are subject to the approval of the District.

C. Uniformity and Standardization

1. Equipment enclosures, assemblies, sub-assemblies, and components that do not differ in operational, functional or performance characteristics shall be designed so that all components are positioned in the same location and internal wiring is routed in between components in a like manner.

a. Equipment providing like functions shall be of the same design and from the same manufacturer.

b. Equipment or devices of the same rating and function shall be identical and interchangeable.

2. Where identical installations exist, the following requirements shall be adhered to:

    a. Unless Jobsite conditions prevent it, equipment enclosures shall be mounted and installed in a like manner.

    b. Penetrations for conduit, grounding, and access panels shall be located in the same place.

    c. The location of equipment relative to adjacent equipment shall not differ.

    d. The routing of conduit, cable tray, wireway, and cables between equipment enclosures shall not differ.

    e. Termination hardware shall be located in like manner.

    f. Cables and wire terminations shall be located in like manner.

D. Equipment Construction

1. General Requirements

    a. The surfaces of the equipment shall be smooth, free of gaps, burrs, sharp edges, wrinkles, waves, or blemishes and shall have uniformly rounded corners with constant radii.

    b. Full height doors for equipment such as switchgear and cabinets shall have a three-point locking latches where applicable and 1/4-turn “tee” handles for exterior equipment. For doors four feet or less in height, two-point locking latches are permitted. Each door shall be provided with a cylinder lock or provision for padlock.

    c. Openings and mounting holes for front-mounted indicating and control devices shall be cut out or punched without marring or distorting the exposed finished surfaces.

    d. Surfaces to be welded shall be clean and free of dirt, rust, and other foreign materials in accordance with industry standards. All welding shall be performed by electric arc method or resistance spot welding, and the process shall conform to the standards of the American Welding Society.

    e. Equipment enclosures shall be provided with grounding lugs.

    f. All items, which require inspection, operation, or maintenance, shall not be higher than 72 inches off the finished floor and shall be accessible from the front or the rear.

2. Arrangement

   a. Equipment arrangements indicated are intended to fit the available spaces while providing adequate personnel safety and accessibility for maintenance. Prepare equipment arrangement drawings using actual dimensions of individual equipment and maintaining the same minimum equipment clearances and aisle widths. Equipment clearances and aisle widths shall be increased if required for normal operation and maintenance of the furnished equipment.

   b. All equipment and components shall be readily accessible for inspection, maintenance, adjustment, and reading of data. Protective relays and other devices from which data are to be read shall be mounted semi-flush on the front panels.

   c. All control devices mounted on front panels and those requiring replacement or adjustment inside panels or compartments, shall be limited to a mounting height not exceeding six feet.

   d. Devices not on the front panels shall be mounted on the surface of internal panels, accessible by opening the hinged front panel.

   e. Each device shall be located and wired so that it can be serviced without removing the device or other devices.

   f. Devices on the front panel of equipment shall be mounted plumb and square with the lines of the panel, and the mounting shall be as recommended by the device manufacturer.

   g. All potentially energized components shall have 12 inches minimum spacing between energized components or shall be insulated to preclude accidental contact by maintenance personnel.

3. Equipment and Cable Entrance Enclosure/Box Rating

   a. Indoor enclosures shall be rated as NEMA 12/12K.

   b. Outdoor enclosures and enclosure penetrations located above ground shall be rated as NEMA 3R (Weather Proof).

   c. Enclosures located in an underground facility shall be rated as NEMA 12K and comply to the requirements specified in NFPA 130.

   d. Alterative equipment enclosure NEMA classifications, to those noted above, that are suitable for the environment to which the equipment is exposed shall be considered but are subject to the District’s approval.

4. Seismic Design Requirements (for Equipment, Utilities and Related Supports and Anchorages)

   a. Equipment design, including device mounting, supports, materials, and installation methods shall conform to the requirements outlined in IEEE 693.

b. Equipment, conduit, busway, cable tray, and associated mounting hardware and anchors shall be designed to operate in a seismically active area, and shall comply with the special seismic design requirements as specified herein:

1) Equipment, Utilities and Related Supports and Anchorages on New Facilities

a) Seismic design shall comply with the provisions of CBC Section 1613. And ASCE/SEI 7-, Chapter 13 except as modified herein.

b) Traction power system elements, including related traction power, fire protection, ventilation, emergency power and lighting, and communication equipment and related supports and anchorages are considered essential equipment and shall be designed using an Importance Factor, Ip = 1.5.

2) Equipment, Utilities and Related Supports and Anchorages on Existing Facilities

a) Seismic design shall comply with the CBC Section 1613. And ASCE/SEI 7-, Chapter 13 except as modified herein.

b) Seismic design shall consider the relative motions between the points of attachment to the structures.

c) Importance Factor Ip shall be in accordance with the Specifications Section Article 1.07D.4.b.1.b above.

5. Equipment Painting

a. All ferrous metal surfaces of enclosures and equipment shall be factory painted by UL-recognized painting system to prevent rust and painted inside and out per manufacturer's standard unless otherwise specified. Interior brackets, supports, or steel barriers may be unpainted provided they are fabricated from galvanized steel. Standard, off-the-shelf equipment procured from other manufacturers is acceptable with its original paint. Ensure painting shall not obstruct or degrade equipment grounding connectivity.

b. Follow NEMA standards for factory painting procedures for electrical equipment.

c. Unless advised to the contrary the finished equipment enclosure color shall be per ANSI Z55.1; Type 61 light gray, semi-gloss.

d. A gallon of touch-up paint shall be provided at each traction power facility for each paint type used on each equipment enclosure.

e. Refer to Section 34 21 05, Prefabricated AC and DC Equipment Houses and Related Equipment, for additional requirements relating to the AC and DC equipment houses.

f. Refer to Section 34 21 20, AC Busways, for additional requirements relating to the AC busways and supporting structures.

6. Prohibited Materials

    a. No polychlorinated biphenyl (PCB), asbestos, or other materials with known toxicity posing health hazard shall be used in any parts or products of the Traction Power System.

7. Static Signs

    a. Refer to Section 26 05 53, Identification Requirements for identification requirements and the Contract drawings for additional requirements.

    b. Furnish and install static sign to the electric utility metering cubicle that specifies the billing address.

    c. Furnish and install electrical safety signs on all doors and access panels of electrical equipment, and on the outside doors of the AC and DC equipment houses, equipment enclosures, perimeter security barrier and gates, in accordance with applicable industry standards, safety regulations and as prescribed within the BART Facilities Standards.

    d. Furnish and install video surveillance, trespassing, PPE notification, hazardous material and video surveillance signs on all site perimeter entrance gates, and within 50 feet of each perimeter wall/fence corner (where it exceeds 100 feet).

    e. Furnish and install traction power facility designation on each side of the perimeter wall/fence.

    f. Furnish and install parking stall signage.

    g. Furnish and install blue light station signage per NFPA 130.

    h. The wording, size, and other details of the signs shall be per Contract and coordinated with the Engineer as required.

    i. Mount static signs to exterior side of the perimeter wall/fence and equipment enclosures.

    j. Attach signs with stainless steel fence flips and/or pamper proof anchors.

8. Safety Equipment

    a. First Aid Kit: Provide a complete first aid kit in accordance with the requirements of Cal OSHA and the local ordinances at each traction power facility.

    b. Emergency Eyewash: Provide hardlined eye wash system at each traction power facility including drainage to dry well or sewer. Provide, under the eyewash two isolation valves, one for the hot water and one for the cold water, to turn off the hot and cold water and remove the eyewash without shutting down the entire bathroom (or station). It shall have a hot and cold water isolation valve or a single valve down stream of a mixing valve.

    c. Provide a hot-stick at each traction power facility.

d. Personal Protective Equipment: A complete set of Personal Protective Equipment (PPE), as prescribed by the equipment manufacturer and Cal OSHA, shall be provided at each traction power facility. The PPE shall include at least the following:

1) Arc Flash Protection Suit.

2) Eye Protection.

3) Acid/electrolyte-resistant gloves and apron.

e. Coordinate size of PPE with the District prior purchase and delivery to site.

f. Submit design and product and data for specified safety equipment.

9. Single Line Diagram

a. A condensed single line diagram, sized 11 inches by 17 inches, shall be provided in a polyvinyl frame for at each traction power facility in the AC and DC equipment houses.

E. Equipment and Wiring

1. Equipment Arrangement – Preliminary arrangements and locations of equipment, devices, and components are specified in the Contract. Submit detailed and dimensioned arrangement and location drawings for the Districts approval prior to fabrication work. The arrangement shall result in minimum space requirement and optimum accessibility for maintenance; and follow NEMA, NESC, NEC, CEC, PG&E requirements, and industry standards. Equipment, devices, and components shall be arranged to be conveniently accessible and easily visible. Grouping shall be neat, modular, and logical with related functions in proximity. Devices shall be plumb and square with the lines of the panel and mounted as recommended by the manufacturer. Care shall be taken to avoid wiring congestion. All auxiliary devices shall match the general appearance as far as possible with the frames of a compatible dull black. All devices on the panel face shall be semi-flush mounted. Devices and raceways of the same general type shall be manufactured by the same company and shall be similarly arranged and mounted.

2. Accessibility – All equipment and components shall be readily accessible for inspection, maintenance, adjustment, and reading of data. All devices, including protective relays, from which data are to be read, shall be mounted on the front panels. The top-edge of the devices mounted on the front panels and elsewhere shall be limited to a height of 72 inches from the finished floor. The minimum height for the bottom edge of the panel-mounted devices shall be 18 inches from the floor. All other devices shall be readily accessible on the surface of the equipment or by opening a hinged door or panel without removing another device or equipment other than by drawing out the circuit breaker.

3. Equipment Integrity – Equipment as assembled for operation shall have no openings, which would allow the accidental entry of hand tools and the like. Circuit breaker arcing in normal and fault clearing operations shall be controlled to protect the operating personnel and to not jeopardize the structure and/or finish.

4. Equipment Reparability – Equipment furnished under the Contract shall be field repairable to the maximum extent possible, to facilitate on-site maintenance and repair by the District, using its own facilities and personnel. Return of equipment to the manufacturer's facilities, for repair or replacement, shall be required only where necessary to comply with Warranty provisions.

5. Wiring Arrangement – All power and control wiring and labeling shall be the same for all traction power facilities. Termination labels and wire markings shall be used for all similar equipment at all traction power facilities.

6. Wiring and cabling of different applications and/or voltages shall be segregated in accordance with the NEC/CEC.

F. Aesthetics

1. Traction power facility sites, equipment houses and equipment enclosures shall be designed to minimize the adverse visual impact on the areas in which they are located and to comply with the appropriate federal, state, and local architectural and environmental guidelines.

G. Accessibility, Maintainability and Safety Requirements

1. Enclosures shall not be placed in direct contact with equipment foundation and/or perimeter security wall surfaces. Install shims and caulk and grout between buildings or enclosures and concrete.

2. All enclosures shall be clearly labeled and identified on the outside in accordance with the District's naming convention, as specified in the approved design deliverables and approved Shop Drawings. Internal components, raceways, and wires of the enclosures shall be labeled and tagged per approved Shop Drawings.

3. Permanent ladder or steps shall be provided in the design of all underground structures and cable trenches, where the depth exceeds three feet. Metal components of the ladder and steps shall be grounded.

4. Equipment and equipment house final placement shall maintain working clearances per NEC and IEEE and shall not obstruct maintenance vehicle access and movement into and around the traction power facility sites through the gates.

5. Placement of the 34.5 kV junction cubicles, 34.5 kV isolation disconnect switches, and 1,000V DC disconnect switches within traction power facility sites shall not prohibit vehicle circulation around equipment and switchgear houses. Provide working clearances per NEC and IEEE.

6. Provide vehicle barriers within traction power facility sites where vehicle circulation is within ten feet of equipment and equipment houses. Provide removable vehicle barriers and posts as per Contract.

7. Provide vehicle barriers around third party utility equipment in accordance with the requirements of the respective third party utility service providers.

8. Equipment, structural supports, foundations, and containment wall placement shall not impede egress from the AC and DC equipment houses, rectifier transformers and auxiliary transformer to the perimeter gates. Maintain a minimum three foot horizontal and seven foot vertical working clearances for equipment, houses, and structures.

9. Provide level working platforms, with sufficient horizontal clearance in accordance with NEC, CEC and NESC, in front of equipment that will need to be accessed. The height of the working platforms above finished grade shall ensure equipment and components that need to be accessed does not exceed 6 feet above finished working platform surface.

10. Placement of auxiliary equipment, exterior site light fixtures, poles and/or vehicle barriers shall:

    a. Consider vehicle movement in and around the equipment and equipment houses.

    b. Not obstruct equipment removal and/or replacement.

11. The design of the stairway/platform associated with the doorway (at both AC and DC equipment houses) designated for circuit breaker removal/replacement shall include removable handrails.

12. Non traction power cables and/or equipment shall not be placed within the AC and DC cable trenches.

13. The MV cables associated with a circuit shall be physically separated from other circuits and shall not occupy or be routed within the same raceway, cable tray, and conduit within the AC and DC cable trenches.

14. The design of underground structures and cable trenches shall prevent their covers from falling onto cables.

15. The orientation and final placement of the AC and DC equipment houses, rectifier transformers and auxiliary transformers, relative to each other and the perimeter security barrier shall not impede equipment removal and/or replacement.

16. Sump pump structures shall be constructed adjacent to the AC and DC cable trenches and their design shall prevent direct access between sump pump enclosure and cable trenches. Electrical distribution and control equipment associated with sump pumps shall be located at grade.

17. The placement of outlets from sump pump structures and containment areas, and site grading, shall ensure water ingress into underground structures shall not occur and any stagnant water can be easily removed.

18. Where trackside lighting fixtures, power outlets, and equipment are located adjacent to or on the perimeter security barrier, ensure the fixtures are placed within the site limits of the traction power facilities or can be accessed from within the site limits of the traction power facilities without exposing personnel to the trackway right-of-way limits.

Existing traction power facility site layouts may prohibit compliance to some of the above noted requirements. Reference Contract drawings for specific site requirements.

1.09 POWER FOR AUXILIARY DEVICES

A. Power for devices and subsystems used for control, indications, alarms, or supervision functions shall be derived from the 125 V DC station battery system. Separate low-voltage batteries are allowed only as back-up power supply. Back-up batteries, if used, shall automatically recharge after use, upon restoration of normal power supply.

B. Power for other devices may be 120V AC or other voltages per Contract.

1.10 NOISE LEVELS

A. The design of the traction power facilities and/or equipment shall meet the specified maximum allowable noise levels. Equipment design, enclosures with acoustic mitigation capability, and other measures, as appropriate, shall be employed to achieve compliance with the audible noise level criteria.

The noise level outside the traction power facility, measured at 15 feet from any equipment during operation shall not exceed 55 dB. Where site conditions prohibit the noted measurement apply the following noise levels to the available maximum distance at the traction power facilities.

DISTANCE (FEET)	NOISE LEVEL (dB)
1	80
3	69
5	65
7	62
9	60
11	58
13	57
15	55

B. The noise level inside the AC and/or DC equipment houses, measured at five feet from any equipment during operation, shall not exceed 70 dB.

C. Refer to Section 34 21 75, Traction Power System Factory Functional Testing and Section 34 21 80, Traction Power System Field Acceptance Testing for additional requirements.

1.11 FAILURE MODE EFFECTS AND CRITICALITY ANALYSIS (FMECA)

A. As part of the design development process perform a detailed qualitative and quantitative FMECA, in accordance with MIL-STD-1629A, that comprehensively provides an appraisal of all possible ways in which the Traction Power System (and its associated systems, equipment, assemblies, sub-assemblies, components and software) and associated interfaces to other systems may fail under worse case conditions within the intended environmental and operational conditions and, the potential consequence of these failures. The FMECA, as specified in MIL-STD-1629A, shall include the following:

1. Failure Mode and Effects Analysis.
2. Criticality Analysis.
3. Maintainability Analysis/Information.

B. The FMECA shall include, but not limited to, the following systems and/or assemblies, as part of the analysis:

1. AC and DC Equipment Houses.
2. Separable Insulated Connectors.
3. MV Isolation Disconnect Switches.
4. AC Switchgear and AC Circuit Breakers.
5. AC Busway.
6. Rectifier Transformers.
7. Auxiliary Power Transformers.
8. Rectifiers.
9. DC Switchgear and DC Circuit Breakers.
10. DC Disconnect Switches.
11. SCADA System (inclusive of the Mimic Panel and HMI).
12. Emergency and Transfer Trip System.

13. 125 V DC Battery System.

14. IPRs and MPRs.

C. The scope of the FMECA shall only include those elements of the Traction Power System that are part of the Work, as defined in the Contract.

D. Submit the following documentation to the District for review and approval:

1. FMECA Plan.

2. FMECA Report.

E. A previous FMECA report produced in the ten years preceding Contract award can be submitted to the District in lieu of conducting FMECA if the Contractor formally certifies and demonstrates the systems, equipment, assemblies, sub-assemblies, components and software being provided under the Contract meet the following conditions:

1. The design of the systems, equipment, assemblies, sub-assemblies, components and/or software is equivalent to the specified contract requirements without exceptions.

2. The design of the systems, equipment, assemblies, sub-assemblies, components and/or software do not need to be modified/changed to comply to the requirements of the Contract and the submitted FMECA validates this basis.

3. Changes in systems, equipment, assemblies, sub-assemblies and/or components designations do not reflect material changes in their design.

4. The design of the systems, equipment, assemblies, sub-assemblies, components and/or software has not changed in the ten years prior to awarding the Contract.

5. Component suppliers have not changed the fabrication process and/or material sourcing in the ten years prior to awarding the Contract.

F. The design deliverables of the Traction Power System shall include a traceability matrix that demonstrates how the results and recommendations of the FMECA report were incorporated into the final design.

1.12 FAILURE OF ELECTRONIC DEVICES

A. Electronic devices, including microprocessor-based devices, shall be equipped with self-monitoring and self-test features. As a minimum, these devices shall be provided with local indication of device failure, visible on the front panel of the cubicle on which the device is located. The failure of any component shall generate a visible and audible alarm and report to the central monitoring system (C02 panel) of the traction power facility.

B. Where device failure affects the operation, monitoring, and control of the main power circuit that it serves, or causes an unsafe condition, device failure shall be indicated at the C02 panel and an alarm sent to the Operations Control Center (OCC).

C. Failure of a device or loss of its power supply shall not cause false indication, prevent annunciation/indication at the OCC, nor prevent a circuit breaker from being tripped by manual, local, or remote control.

D. Electronic devices shall be designed, manufactured, and installed to prevent unauthorized access and in compliance with Districtwide Operational Technology Infrastructure (DOTi) network security policy.

E. Licenses associated with firmware, hardware, software, and their associated components shall be given to District on Substantial Completion of work. Licenses shall be owned by the District in perpetuity.

1.13 DESIGN LIFE

A. Equipment, cables and other materials shall be designed for the following service life, under the applicable ambient environmental conditions specified below

1. AC and DC switchgear, rectifier transformers, rectifiers, auxiliary power transformers, AC and DC circuit breakers, negative grounding devices, manual disconnect switches, 34.5 kV isolation disconnect switches, and cables: - 30 years.

2. Batteries: - 20 years.

3. Battery charger: - 20 years.

4. SCADA System (inclusive of the Mimic Panel and HMI): - 20 years.

5. Emergency and transfer trip system: - 20 years

6. IPRs and MPRs: - 20 years.

7. Materials shall be new and of the highest quality available for the Work as specified.

1.14 ELECTROMAGNETIC AND ELECTROSTATIC SUSCEPTIBILITY

A. The traction power system’s equipment shall not be adversely affected by radiated or conducted electromagnetic or electrostatic interference from trains or fixed sites and other electric/electronic equipment on or within one mile of the District’s right-of-way including but not limited to the following; trains operating within the guideway, fixed site equipment, cellular telephones, mobile radios, incidental (spurious) radiation equipment, ignition noise, lighting fixture, electrical power system transients, vehicular systems, and electrostatic discharge.

B. Investigate all electromagnetic and electrostatic susceptibility factors that may affect equipment operations both before and after installation of the equipment.

Electromagnetic and electrostatic susceptibility deficiencies uncovered during installation testing, on-line demonstration, or final tests may be cause for additional design adjustments and additional testing at no additional cost to the District.

1.15 PROJECT ENVIRONMENTAL CONDITIONS

A. The Traction Power System shall operate continuously in the follow operating environment:

1. Elevation: The lowest and highest part of the alignment where traction power facilities are located adjacent too is between 0 feet and 1000 feet respectively above sea level.

2. Temperature: Refer to the BART Facilities Standards, Introduction, Operations Common Data, Climate and Seismology for the annual atmospheric ambient temperature range in degrees Fahrenheit.

3. Relative Humidity: Refer to the BART Facilities Standards, Introduction, Operations Common Data, Climate and Seismology for the annual relative humidity range as a percentage.

4. Typical Wind Conditions: Refer to the BART Facilities Standards, Introduction, Operations Common Data, Climate and Seismology for the annual mean wind speed and maximum wind speed.

5. Rainfall: The following rainfall levels shall be assumed:

    a. Normal Annual: Refer to the BART Facilities Standards, Introduction, Operations Common Data, Climate and Seismology for the range in inches.

    b. Maximum in 24-hour period: Refer to the BART Facilities Standards, Introduction, Operations Common Data, Climate and Seismology for the maximum in inches.

    c. Maximum in one-hour period: Refer to the BART Facilities Standards, Introduction, Operations Common Data, Climate and Seismology for the maximum in inches.

    d. 90 percent of Average Annual Precipitation occurs between November and April.

6. Floods: The Traction Power System shall be designed for the peak run-off from a 100-year storm.

7. Snowfall, Ice Pellets, and Icing: The District’s alignment experiences minimal levels of snowfall, ice pellets, and icing; and therefore, their impact on the design of the Traction Power System shall be ignored.

8. Number of Thunderstorm Days per Year: Refer to the BART Facilities Standards, Introduction, Operations Common Data, Climate and Seismology for the number of days per year to be assumed.

9. Fog: Heavy fog is common to some areas of the District's alignment and therefore shall be assumed, for design purposes, for the complete alignment.

10. Soil Resistivity: Refer to the supporting documentation provided as part of the Contract.

11. Seismic: The District's alignment and associated support facilities are in a seismically active area. Refer to the BART Facilities Standards Design Criteria, Structural, Seismic Design for specific requirements.

12. Atmospheric Pollution/Contamination: Refer to the supporting documentation provided as part of the Contract.

13. Hazards and Hazardous Materials: Refer to the supporting documentation provided as part of the Contract

B. Equipment and devices inside traction power facilities shall be designed and rated for operation at 50 degrees Celsius ambient temperature.

1.16 DESIGN CRITERIA – LOW VOLTAGE CIRCUITS

A. The following criteria for voltage drop shall apply to the low voltage circuits and the Contractor shall demonstrate compliance to the requirements through the calculations noted below:

1. Sensitive Electronic Equipment (e.g. C02 HMI, IPRs, MPRs, fiber optic media converters, network switches, PLCs)

   a. 1.5 percent or less on branch circuit conductors.

   b. 2.5 percent or less on combined feeder and branch circuit conductors.

2. LV Power and Lighting Circuits, and 125 V DC Control Power Circuit

   a. Three percent or less on feeder circuit conductors at the farthest field device in the circuit.

   b. Five percent or less on combined feeder and branch circuit conductors at the farthest field device in the circuit.

1.17 DESIGN DELIVERABLES

A. Refer to General Conditions (GC 4.12) and associated Supplemental Conditions for the terms and conditions relating to work product ownership.

B. Refer to the following Sections for additional requirements:

1. Section 01 33 00 Submittal Procedures.

2. Section 01 33 23 Shop Drawings, Product Data and Samples.

C. General

1. All deliverables shall be signed and sealed by a Professional Engineer licensed in the State of California.

2. Refer to Section 01 43 00, Quality Assurance, Section 01 45 00, Quality Control, and Section 34 21 01, General Requirements for the Traction Power System for the quality control, quality assurance and qualification requirements.

3. The Traction Power System shall be compliant with the Federal, State, and local ordinances, industrial publications and the BART Facilities Standards requirements as specified in the Contract.

4. Coordinate the design with the third party utility service providers' existing infrastructure and ensure the design complies with their respective design standards outside the District's Right-of-Way (ROW). Within the District's ROW comply to the requirements specified in the Contract.

5. Coordinate the design of the Traction Power System with the respective designs of the Architectural, Civil, Structural, Utility, Mechanical, Electrical and Systems disciplines.

6. All design deliverables shall be produced in accordance with the CADD requirements as set forth in the BART Facilities Standards.

7. Calculations:

   a. Calculations and studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in the Contract. An organization experienced in the application of computer software used for calculations and studies, having performed successful calculations and studies of similar magnitude on Traction Power System using similar devices.

   b. Calculations and studies shall utilize equipment, component, wire, fiber strands and cable designations that correlate with product and design deliverables specified herein and elsewhere in the Contract.

8. Where products specified in the Contract, are required to conform to the standards of organizations such as ANSI, ASTM, NEMA, and UL, the Contractor shall submit evidence of such conformance to the District for review and record purposes.

9. All submittals specified in the Contract shall be submitted for review and approval with ample time to prevent delays in the Work. Additionally, the sequencing of submittals needs to consider their inter-relationship and shall be reflected in the Contractor's Project Schedule.

10. The Traction Power System design submittals shall be organized in separate packages, containing at a minimum the following:

    a. Main Traction Power Equipment. Included in the package shall be the AC and DC equipment houses and all equipment inside them, as well as all other surface mounted equipment on the traction power facility sites, such as rectifier transformers and auxiliary power transformers.

    b. Emergency and Transfer Trip System (ETTS). This package shall cover all ETTS related devices and subsystems, including fiber optic and control cabling, equipment in train control rooms, wayside blue light stations, and platform trip stations.

    c. Traction Power Feeders and Raceways. Included in the package shall be 35 kV cables, 34.5 kV system raceways, elbows and bolted type connectors, 34.5 kV junction cubicles, 34.5 kV isolation disconnect switches, 34.5 kV splices and splice boxes, 34.5 kV spark gap assemblies, 2.4 kV DC cables for positive and negative return feeders, DC raceways up to the track side and termination details, associated accessories, and cable pulling calculations for the AC and DC feeders.

    d. Traction Power Siteworks. Included in this package shall be site plans for each traction power facility, foundation design including trenches and cable trays near and under AC and DC equipment houses, all underground raceways within the TP site boundaries, ground grid design and grounding details, and civil aspects of the site design, such as paving, fencing and access provisions. Furnish survey for existing underground utilities, identifying utility owners, coordination with those utility owners, cities, and other entities as required for a resolution or relocation of existing underground utilities, so as not to have any conflicts with the new traction power system.

    e. Interfaces with the existing BART System. Included in this package shall be all designs related to the interface of the Traction Power System with the existing BART System, including modifications to existing BART facilities and equipment.

    f. Contact Rail System Components. This package shall include the design of individual components of the contact rail system, including hardware for interfacing with the positive traction power feeders and jumper cables.

    g. Contact Rail System Layouts. This package shall include scaled drawings showing the detailed and final design of the contact rail system. The drawings shall include exact locations of end-ramp assemblies, gap dimensions, anchor assemblies, expansion joints, contact rail jumpers and dc feeder connection plates.

    h. Contact Rail System Installation Details.

11. Hard and soft copies of the deliverables shall be submitted to the District.

12. In the case of studies:

    a. A separate CD of the original source format of input data used as direct input to the selected software to perform the calculations, generate the reports, generate the tabulations, plot the curves and graphs, and the list the device settings for the as-built facilities shall be submitted to the District.

    b. The name and manufacturer of the software utilized to perform the calculations, prepare the reports, make tabulations, plot the curves, graphs, and drawings with the specific version used. This specific reported software shall be able to take the original source format information submitted above and generate associated tabulations, plot the curves and graphs, perform the calculations, and list the device settings for the as-built facilities submitted as paper and electronic copies. Submit all setup information for using the software used to generate the studies and reports submitted.

13. The design deliverables shall account for the spares requirements as specified elsewhere in the Contract.

14. Refer to the individual equipment Sections listed in Art. 1.02 above for additional requirements.

D. Traction Power Equipment Vendor Deliverables

1. Product Data

    a. Product data shall be provided for all equipment, cables, materials and appurtenances provided under the Contract.

    b. Product data shall include, but not limited to, the following

        1) Modify manufacturers' standard schematic drawings to delete information that is not applicable to the Contract. Supplement standard information with additional information applicable to the Contract.

        2) Modify manufacturers' standard catalog cuts, brochures, diagrams, schedules, performance charts, illustrations, calculations, and other descriptive data to delete information that is not applicable to the Contract. Indicate dimensions, clearances, performance characteristics, capacities, wiring and piping diagrams, and controls.

        3) Modify manufacturer's printed installation, application, and instructions to delete information that is not applicable to the Contract.

2. Product Shop Drawings

    a. Product shop drawings shall be provided for all equipment provided under the Contract.

b. Product shop drawings shall include, but not limited to, the following:

1) Assembly drawings.

2) Dimensional information (including clearances to adjacent equipment/etc.)

3) Internal physical arrangement and assembly of detail parts in each item of equipment.

4) Mechanical and electrical details.

5) Wiring and connection diagrams.

6) Wiring numbers between devices and equipment terminal blocks.

7) Elementary schematic drawing number where the device appears.

8) Brief description of the device functions and special features.

9) Manufacturer's name.

10) Manufacturer's part, model, type or style number.

11) Device rating.

12) Number, type and rating of contacts, if applicable.

13) Internal schematic diagrams.

14) Outline of device and external terminal locations and numbers.

3. Site Specific Design Package

a. Site specific design packages shall be provided for each new traction power facility, AC switchgear house, DC switchgear house, rectifier transformers and/or ancillary transformer provided under the Contract.

b. Site specific design packages shall include, but not limited to, the following:

1) Table of Contents.

2) Symbols, abbreviations, device tables, equipment designations, and notes used on all design drawings.

3) Arrangement drawings showing locations of control and protective devices on panels.

4) Floor plans of complete equipment assemblies showing dimensions necessary for installing equipment, equipment base details, available space for entrance of power, control and communications cables, and dimensions and weights of major sections.

5) Section views of each non-identical unit showing bus and equipment locations and locations of outgoing power and control terminals. Drawings shall be in sufficient detail to illustrate accessibility for maintenance and for adjustments while energized.

6) Single-line meter and relay diagrams.

7) Schematic diagrams of equipment assemblies showing devices, wire numbers, internal and external wiring. Diagrams that do not portray the physical wiring of the panel will not be approved.

8) Schematic diagrams and technical data for the automatic reclosing and load measuring system.

9) Emergency and Transfer Trip System (ETTS) drawings. These drawings shall show all components, functionality and operational logic of the ETTS. The emergency trip system drawings shall also indicate the locations of all platform trip stations and wayside emergency trip (blue light) stations, and the associated wiring diagrams.

10) Functional, logical and schematic diagrams of the ETTS equipment, including individual devices and interfaces with the dc switchgear, and with wayside emergency trip and platform trip stations.

11) Multifunction relays and PLC interface drawings. These drawings should show the multifunction protective relays on the dc and AC side of the traction power facilities and their interfaces, and the interfaces of the traction power facility's programmable logic controller (PLC).

12) Physical layout, functionality and control schematic drawings for the control panel (C02).

13) Layout, equipment arrangement, annunciation, metering and control functions of the traction power facility's C02 panel, including C02 PLC interfaces, settings, display screens, logical diagrams and functionality.

14) Traction power facility C02 PLC and ETTS SPC data and details, including logical and functional diagrams, as required for all aspects of operation and maintenance. Similar for all communication interface devices in the traction power facility, such as Ethernet switches, media converters, and Ethernet input/output modules.

15) Communication interfaces and schematic diagrams for the inter-device communications within the traction power facility.

16) Logic diagrams.

17) Detailed SCADA points lists drawings.

18) Programmable logic controller (PLC) annunciation/alarm screens. Layouts, alarm messages and functions.

19) DC circuit breaker control schematic drawings, including all multifunction protective relay (MPR) interfaces, SCADA, local control interfaces and interlocking, as appropriate.

20) AC circuit breaker control schematic drawings, including integrated protective relay (IPR) interfaces, SCADA, local control interfaces, and auto-transfer logic, as appropriate. For 34.5 kV sectionalizing breakers, also interlocking logic with adjacent switching stations and measures for prevention of accidental paralleling of adjacent 34.5 kV circuits supplied by different high-voltage substations.

21) NGD control schematics.

22) Low voltage power, lighting, heating and ventilation, and miscellaneous system drawings within the AC and/or DC equipment houses.

23) Grounding system drawings within the AC and/or DC equipment houses, rectifier transformers and AC busways.

24) Structural drawings for AC and DC equipment houses, and equipment mounted within the houses.

25) Structural drawings inclusive of anchorage for the AC busway supports.

26) Plans and side views, equipment arrangement, and installation details of the 34.5 kV junction cubicles and/or 34.5 kV isolation disconnect switches interfacing the along-track 34.5 kV distribution feeders with the traction power facilities.

27) Nameplates and signs showing legends, letter sizes, material, and color information.

28) Equipment nameplate data, catalogue cuts, data sheets and recommended spare parts lists.

29) Connection diagrams showing the internal wiring and terminal block arrangement and identifying each outgoing power and control terminal.

30) Complete equipment and intrabuilding raceway layout drawings, including the raceway and circuit schedules.

31) Detailed instructions for connecting the various shipping sections together complete with connection diagrams. The connection diagrams shall identify the terminals to be connected between the shipping sections, and the type and size of cables required for the connections.

32) Default settings, parameters and menus of all multi-function relays

33) Settings, access details and operational details of the facility’s alarm and annunciation panel/screen.

34) Metering and data retrieval devices and related details.

35) Switchgear breaker test value of the transient recovery crest voltage and the time to reach transient recovery crest voltage.

36) Transformer data including rated kVA, frequency, primary and secondary voltages, percent taps, polarity, impedance and certification of transformer performance efficiency at indicated loads, percentage regulation at 100 percent and 80 percent power factor, no-load and full-load losses in watts, percent impedance at 75 degrees Celsius, hot-spot and average temperature rise above 40 degrees Celsius ambient temperature, sound level in decibels, and standard published data.

37) Fire alarm system layout plan, schematics and notes.

38) Any supplementary data required by the District to assure that the Contract has been accurately interpreted.

c. Where modifications are made to existing traction power facilities/equipment the Contractor shall electronically reproduce the District furnished as-built/record drawings and revise them to reflect the modifications. Provide supplemental site specific design drawings to the reproduced and modified drawings as required.

d. In addition to the design development in-progress and final submittals, per Section 01 33 00, Submittal Procedures provide as-shipped (to site) site specific designs that incorporate all changes made in the factory prior to shipment to the Jobsite.

4. Calculations

a. Calculations shall be provided for each new traction power facility, AC equipment house, DC equipment house and/or rectifier transformer provided under the Contract.

b. Calculations shall include, but not limited to, the following:

1) Design calculations for the transformer-rectifier unit, including transformation ratio, commutating reactance, transformer impedance, no-load and full-load power losses, dummy resistors, and extended voltage regulation curve from 100 percent load to short circuit on the dc bus.

2) Indoor and outdoor lighting calculations (associated with AC and DC equipment houses).

3) 480 VAC and 125/24 VDC system design calculations, including cables and all equipment sizing, including circuit breakers, fuses, transformers, dc/dc converters, battery chargers and batteries.

4) Structural design calculations (for AC and DC equipment houses, equipment within AC and DC equipment houses, rectifier transformers, AC busway structural supports). Structural calculations shall be in accordance with CBC and other seismic criteria. Calculations shall be signed and stamped by a Professional Civil or Structural Engineer currently registered in the State of California.

5) Seismic calculations (including bracing and support of equipment and devices). Seismic calculations shall be in accordance with CBC and other seismic criteria. Calculations shall be signed and stamped by a Professional Civil or Structural Engineer currently registered in the State of California.

6) Noise level calculations and related abatement measures.

7) Design calculations for miscellaneous systems and devices.

5. Studies

a. Studies shall be performed and provided for each new traction power facility, pre-engineered AC equipment house, pre-engineered DC equipment house and/or rectifier transformer provided under the Contract.

b. General

1) The studies shall include single-line and impedance diagrams of the portions of the Auxiliary Power Distribution System that are electrically connected to the traction power facilities. These diagrams shall identify all components considered in the studies and the ratings of all power devices, including transformers, circuit breakers, relays, fuses, busses, and cables; including initial recommended settings and final settings per manufacturer's recommendations. The resistances and reactances of all cables shall be identified in the impedance diagram. The studies shall contain all written data from the Electric Utility Service Provider regarding maximum available short circuit current, voltage, and X/R ratio of the Electric Utility Service Provider's power system. Similar information shall be requested from the District for the 34.5 kV sub transmission system.

2) The studies shall include all protective devices and feeders included under this Contract. The studies shall include all Auxiliary Power Distribution System existing upstream protective devices and feeders supplying the new loads under the Contract. The Electric Utility Service Provider's overcurrent protective device and ground fault protective device for the Electric Utility Service Provider's circuit breaker delivering power to each of the facilities shall be used as a fixed reference and starting point for these studies. Similar information shall be requested from the District for the 34.5 kV sub transmission system.

3) The studies shall cover three-phase faults and the line to ground faults to coordinate over-current settings and ground fault settings for proper coordination and protection.

4) Electrical load calculations (for sizing feeder and branch circuit breakers, disconnect switches and conductors).

5) Voltage drop calculations.

6) Site lighting analysis and calculations.

7) Ground grid design calculations.

8) Calculations associated with electromagnetic compatibility.

9) Equipment sizing/rating calculations.

10) Low voltage (AC and DC) systems design calculations, including circuit sizing based on voltage drop and current loading, panelboards, and selection of protective devices.

11) Calculations for field installed conduit and cable tray fill, and for cable-pulling in conduit.

12) Calculations for sizing equipment enclosures and boxes in accordance with NEMA, NEC, CEC, or NESC.

13) Contractor shall:

a) Obtain from the Electric Utility Service Provider, the District and appropriate vendors the information required to perform all the studies specified in the Contract.

b) Contact the Electric Utility Service Provider, the District and obtain the fault data, short circuit contribution, impedance values, and X/R ratio in writing for each traction power facility. A copy of each of the letters shall be submitted to the District and be included in all reports.

c) Contact the protective device manufacturers and obtain the ratings and time current curves for all protective devices including fuses, circuit breakers, motor circuit protectors, relays and overload elements.

d) Perform all needed field investigation and inspections to properly identify protective devices and their settings and ratings to get the correct information to work with including the correct trip and/or time-current curves.

e) Perform all needed field investigation and inspections to properly identify equipment and any appropriate settings and nameplate data to get the correct information to work with including impedance values, voltage ratings, base kVA ratings and/or current ratings.

f) Perform all needed field investigation and inspections to properly identify all cable and wire size, type, size and material for use in the studies.

g) Determine the cable and wire lengths and protective conduit type (plastic, fiber glass) for use in the studies.

c. Studies shall include, but not limited to, the following:

1) Short Circuit/Fault-Current Study: The study shall provide interrupting ratings of equipment overcurrent protection devices and conductors for all non traction power equipment, components, wires, and cables located at traction power facilities.

2) Protective Device Coordination Study: The study shall include coordination on protective relay characteristics and settings, ratios and characteristics of associated current transformers, power fuses, circuit breaker trip characteristics and settings, and AC surge arresters and grounding requirements.

3) Arc Flash Study: This study shall calculate, determine, and report the "arc flash protection boundary", incident energy, voltage shock hazard, limited/restricted and prohibited approach boundaries, "personal protective equipment" level, and safety label design (including specific information to be communicated on the labels) that should be posted on non traction power equipment. This study shall be performed in conjunction with the short circuit calculations and protective device coordination, and the results shall be tabulated with all identified equipment or short circuit interrupting items in the short circuit and protective device coordination studies.

E. Traction Power Cables and LV (Non-Traction Power) Equipment Vendor Deliverables

1. Product Data

a. Product data shall be provided for all equipment, cables, materials and appurtenances provided under the Contract.

F. Professional Architectural/Engineering Design Deliverables

1. Construction Drawings

a. Construction drawings shall be provided for all traction power facilities, inter and intra building raceway/ductbank systems and/or traction power system equipment located in ancillary spaces (e.g. train control rooms/houses) provided under the Contract.

b. Construction drawings shall include, but not limited to, the following:

1) Table of Contents

2) Symbols, abbreviations, device tables, equipment designations, and notes used on all design drawings.

3) Track plans, sections and details.

4) Civil site plan, sections, elevations, details and geometry data.

5) Grading, drainage and paving plans, sections, elevations and details

6) Composite plans, sections and details of utility rearrangements.

7) Equipment foundation plans, sections, elevations and details.

8) Perimeter security barrier and gate plan, sections, elevations and details.

9) Mechanical site plans, sections and details.

10) Grounding grid, bonding systems design, including ground test stations, ground bus, and grounding conductor layouts and equipment enclosure grounding details.

11) Inter and Intra building underground ductbank plans, elevations, sections and details.

12) AC and DC cable trench plans, elevations, sections and details.

13) Exposed conduit arrangements plans within the traction power facilities and/or ancillary spaces.

14) Equipment and field device layouts drawn to scale and showing physical dimensions and layouts shall consist of:

    a) Plan views, including floor plans of complete equipment assemblies showing also clearances necessary for installing equipment, equipment base details, available space for entrance of power and control cables, and preliminary dimensions of major sections.

    b) Elevation views, showing locations of control and protective devices on panels.

    c) Section views of each non-identical unit, showing bus and equipment locations, accessibility for maintenance and power and control cable entrances.

15) Drawings depicting the traction power facility, adjacent tracks and interconnecting underground ductbanks, and other related interfacing equipment and facilities.

16) Single-line metering and relay diagrams.

17) Cable block diagrams

18) Cable routing plans.

19) Power and lighting plans.

20) Low voltage (480 V AC, 240 V AC and 120 V AC) detailed systems design, including panelboards, protective devices, loads, and conductor sizing.

21) Mounting details for field installed equipment, conduit, cable tray and mounting hardware.

22) Auxiliary equipment (e.g. transformer) schematic diagrams.

23) Detailed development of schedules (conduit/cable tray, underground structures, panelboards and cables) in accordance with the templates provided in the Contract.

24) Underground structure development plans depicting conduit sizes and allocation on all surfaces.

25) Complete equipment and device nameplate data, and warning signs; including legends, letter sizes, material, and color information.

26) Contact rail schematic.

27) Contact rail layout plans.

28) Contact rail localized layout plans (e.g. special trackwork, MOWs, pedestrian crossings, etc.).

29) Contact rail system installation and component details.

30) Trackside manual disconnect switch installation plan, d=sections, elevations and details.

31) Incidental/miscellaneous details.

2. Technical Construction Specifications

a. Where the contract technical requirements are not signed and sealed by a licensed Professional Engineer for the scope of work detailed in the Contract, the Contractor shall provide 100 percent technical construction specifications (that represents the Contractor's design) signed and sealed by their Professional Architectural/Engineering sub-contractor.

G. Closeout Procedures

1. Refer to Section 01 77 00, Closeout Procedures and Section 01 78 39, Contract Record Documents for additional requirements.

2. Provide hard and electronic copies in accordance with Section 01 33 00, Submittal Procedures of the approved product and design deliverables, updated to account for final as-built and tested conditions, specified herein and elsewhere in the Contract.

1.18 ASSET MANAGEMENT

A. Provide the following information for every system, piece of equipment, assemblies, sub-assemblies, components and software provided under the Contract:

1. Manufacturer's Name, Address, Email Address, and Contact Telephone Number.

2. Description and Model Number.

3. Unique Identifier (e.g. Part #, Serial #) inclusive of design revision.

4. Location where the entity is installed (e.g. MPR xxx is installed at TPF xxx, Circuit Breaker 172-xx)

5. Dates of manufacture, on-site installation and put into revenue service.

6. Cross references to documentation (e.g. design, O&M manuals, test records, maintenance procedures and required frequencies, equipment settings as delivered, etc.)

B. The information shall be formatted in accordance with the District's asset management register requirements prior to submission to the District. Reference Attachment A for the format.

1.19 ADMINISTRATIVE REQUIREMENTS

A. Refer to the following Sections for additional requirements:

1. Section 01 31 19 Project Meetings.

2. Section 01 32 16 Construction Progress Schedules.

3. Section 01 35 14 Operating System Interface.

4. Section 01 35 24 Construction Safety.

5. Section 01 35 33 Security Procedures.

6. Section 34 21 70 Traction Power Facilities Installation Requirements.

B. As the Work, detailed in Section 01 11 00, Summary of Work and elsewhere in the Contract, is on and/or adjacent to operational trainway, operational facilities, Public ROW and/or facilities operated by third parties, the construction and testing activities shall be managed to minimize the impact and risks to revenue services, public and third party personnel within the working hours noted elsewhere in the Contract.

C. Sequence and schedule all construction and testing activities to ensure adequate time allowances for

1. Work plan, track allocation, and other approvals.

2. Pre-planned/known special events undertaken by the District and/or third parties.

3. Scheduled routine maintenance by District personnel.

4. Scheduled work activities by other contractors working on the District.

D. Conduct pre-activity meetings at least seven calendar days prior to scheduled activities with all applicable stakeholders. Notify all stakeholders of cancelled construction and/or testing activities no later than two calendar days prior to planned start date.

1.20 DELIVERY, STORAGE AND HANDLING

A. Refer to Section 34 21 70, Traction Power Facilities Installation Requirements for requirements.

1.21 JOBSITE CONSIDERATIONS

A. Examination

1. Examine areas and conditions.

2. Note items that may infringe on the necessary clearances and other non-compliances. Promptly bring noted issues to the attention of the Engineer for direction and approval before proceeding.

B. Protection

1. Protect and secure the Jobsite until final acceptance of the Work by the District. Damage to and/or lost equipment, materials and/or cables shall be replaced, re-installed and retested (as applicable) by the Contractor at no additional costs to the District.

2. Protect in-place existing installations delineated on the Contract Drawings. Damage to existing installations shall be repaired by the Contractor at no additional costs to the District.

3. Refer to Section 34 21 70, Traction Power Facilities Installation Requirements for additional requirements.

C. Maintenance

1. Maintain equipment furnished under this Contract in accordance with the manufacturer's recommendations and statutory requirements until final acceptance of the Work by the District.

D. Cleaning

1. Refer to Section 01 74 14, Cleaning, for additional requirements.

2. Remove all waste materials from the Jobsite(s) at no additional cost to the District.

1.22 WARRANTY

A. Refer to the General Condition and Supplementary Conditions for additional requirements.

B. Contractor shall ensure that apart from batteries, a warranty for the complete Traction Power System is provided and signed by the equipment manufacturer and the Contractor agreeing to correct system deficiencies and replace components that fail in materials or workmanship.

C. Provide extended warranties for equipment as prescribed herein:

1. Warrant AC and DC equipment houses to be free from defective materials and workmanship, water leakage and seepage, and condensation for a five-year period commencing at the completion of the standard two-year warranty.

2. Warrant rectifier transformers to be free from defective materials and workmanship, for a five-year period commencing at the completion of the standard two-year warranty

3. Warrant batteries to be free from defective materials and workmanship for one year from the date the battery is placed into revenue service and 19 years, pro rata, to deliver not less than 80 percent of its rated capacity.

1.23 CLOSEOUT SUBMITTALS

A. Refer to Section 01 77 00, Closeout Procedures, and Section 01 78 39, Contract Record Documents, for additional requirements.

B. Provide hard and soft copies of the following documentation:

1. Permits.
2. Operations and Maintenance Manuals.
3. Training Manuals.
4. Record Documentation.
5. Equipment Vendor Design and Product Deliverables.
6. Guarantee and Warranty Documentation.

C. Software

1. Provide a listing of “as-built” passwords for all software products furnished under the Contract.
2. Provide six electronic copies of all software associated with the operation of each traction power facility and their associated equipment, including but not limited to the following equipment provided under this contract:
    a. RTAC and HMI at the C02 Cabinet.
    b. Emergency transfer trip system.
    c. Sectionalization breaker blocking scheme.
    d. Negative ground device.
    e. MPRs and IPRs.
    f. 125 V DC battery monitoring system.
    g. Communication switches, routers and/or signal processing equipment.
    h. Fire detection system.
    i. Access control system.
    j. HVAC controller.

1.24 MAINTENANCE MATERIAL

A. Provide a complete list of all spare parts (including testing spare parts if purchased by the District) and tools to be delivered to the District.

B. Provide secure storage facilities for the spare parts and tools (for up to six months).

C. Coordinate delivery of the spare parts and tools with the Engineer.

D. Provide keys that were furnished with the equipment and materials to the Engineer.

PART 2 – PRODUCTS

Not Used

PART 3 – EXECUTION

3.25 TRAINING

A. Guidelines

1. The Contractor shall provide a training program to enable District personnel to operate, service, test, and maintain the hardware, software, and firmware such that the equipment and systems will perform in accordance with the Contract requirements. The training will be attended by District Maintenance, Engineering, and Training personnel.

2. Training shall not commence until the Engineer has approved the Student Training Materials indicated in this Contract Specifications Section and the Pre-Final Submittal of the Operations and Maintenance Manuals.

3. Training shall be provided by or certified by the primary manufacturers of the contract equipment and software.

4. The initial 240 hours of training shall be completed prior to Acceptance of any equipment.

5. Training shall be provided in accordance with Contract Specifications Section 01 79 00, Demonstration and Training.

6. The training program shall include formal and informal hands on instruction during installation, as appropriate. Provide models, mock-ups, laboratory equipment setups, documentation and aids to carry out the program.

7. Training shall include equipment maintenance and troubleshooting, and using laptop computers for review and checkups for the settings of protective relays, downloading relay event logs and saved event data, and access to programmable logic controller (PLC) data and configuration.

8. Assume that the personnel to be trained have basic electrical skills and experience pertinent to their craft as outlined in District’s job descriptions for the involved personnel.

9. The District will furnish space for classroom lectures and equipment training.

B. Instructors

1. The principal instructors provided by the Contractor shall have previous formal classroom instruction training and relevant experience with the provided systems equipment in an operating environment. Submit instructor qualifications and experience 90 days prior to training.

C. Training Materials and Equipment

1. The Contractor shall prepare training course materials, including basic and advanced training program plans, instructor guides, student training materials, and equipment used in classroom demonstrations and hands-on training as described below and submit them to the District for review and approval 90 days prior to the start of the classroom instruction.

2. Provide demonstration PLC and relay equipment for classroom familiarization with the equipment. The equipment shall be powered and operational, allowing students to gain familiarization with equipment operation before operating the equipment in the field. For basic training classes provide one demonstration model of each equipment for every six students. For advanced training classes provide one operational piece of equipment for every three students. The Contractor may use spare parts furnished under this Contract as training aids for demonstration and for practical exercises in adjusting, testing, disassembly, and assembly of equipment. Ensure that the spare parts so used are repackaged and returned to the District spare parts storage in their original condition.

D. Training Program

1. The Training Program shall include formal instruction with the Contractor providing any models, mockups, documentation, and aids used to carry out the Training.

2. Assume that District’s personnel to be trained have basic knowledge of existing BART traction power system systems and equipment similar to those to be taught in the classroom. However, assume that trainees have no specific knowledge of the features of equipment, protective relay, and PLC features such as controls, protection, metering, and monitoring functions of equipment or systems provided by this Contract. The Contractor may request the job descriptions from the Engineer.

3. BART maintenance staff work on three shifts:

   a. Day: 7am - 3pm

   b. Swing: 3pm - 11pm

   c. Graveyard: 11pm - 7am

4. The District will try to accommodate all instruction during the day shift. However, the Contractor shall accommodate teaching during all three shifts as necessary.

E. Training Program Plan

1. The Contractor shall submit the Training Program Plan in the data package for the Final Design Review as indicated in Exhibit A - Preliminary Submittals List and shall include the following:

   a. The overall objective(s) of the Training Program.

   b. A matrix describing each training day including subject(s) to be covered, measurable objectives, type(s) of instruction, time allocation, materials and equipment requirements, and criteria and methods of evaluating achievement of each objective.

   c. Any special electrical power or other infrastructure requirements for the training site.

   d. Criteria and methods for evaluating achievement of overall program objectives.

   e. Training Schedule closely corresponding to the Training Program milestones as indicated in this Contract Specifications Section.

   f. Training plan shall include written test to evaluate students' grasp of the material presented.

F. Instructor's Guide

1. The Instructor's Guide shall detail the actions of the instructor during the staged Training Program. There shall be one section for each objective of the Program, and the sections shall be arranged as follows:

2. Section 1. - Title: The title shall be short and descriptive. It shall contain the lesson name and, if applicable, the target population (example: Auxiliary Electric Subsystem Theory of Operation for Traction Power System Technicians).

3. Section 2. - Time To Teach: An estimated time to teach shall be designated for each subject. This is an approximate time frame which shall be variable to accommodate student number and knowledge level.

4. Section 3. - Objective: Each Instructor's Guide shall have one or more performance-based objectives. Each objective shall specify:

   a. End-of-course behavior expected to be demonstrated by the student.

   b. Conditions under which the behavior will be demonstrated.

   c. Measurable minimum level of behavior considered acceptable.

5. Section 4. - References: All sources of materials presented in the Instructor's Guide shall be fully cited. This shall include Operations and Maintenance Manuals, Test Equipment Manuals, other manuals or other documents, including District documents, utilized to develop the training.

6. Section 5. - Equipment and Materials List: List all equipment and materials needed to teach the course material in the Instructor's Guide. This includes size and type of facility; all instructional aids such as overhead transparencies and/or charts and applicable projectors; student handouts such as books, drawings, schematics; and equipment such as tools and parts for disassembly.

7. Section 6. - Introduction: The introduction shall cover at least the following areas:

    a. Introduction of the subject covered by the lesson.

    b. Objectives of the lesson.

    c. Outline of the lesson.

    d. Schedule of the lesson activities.

8. Section 7.- Presentation

    a. The presentation shall be in outline form.

    b. The presentation portion of the Instructor's Guide shall be detailed enough to:

        1) Allow another instructor with knowledge of the area to teach the class.

        2) Ensure that the subject delivery is consistent each time the lesson is given.

        3) Serve as a written record of the specific information presented.

        4) Cover all tests, quizzes, and other evaluations conducted in conjunction with the lesson.

        5) Ensure that all facts and information the trainees receive are written in the guide or referenced.

9. Section 8. - Attachments

    a. The following materials shall be supplied with each Instructor's Guide:

        1) Reproducible "A"-size copies of any overhead transparencies used with the lesson.

        2) Slides, pictures, charts, video, or magnetic media used in support of the lesson.

        3) Complete student handout package.

        4) Copy of any referenced material used in the lesson.

G. Student Training Materials

1. One complete set of Student Training Materials shall be provided for each scheduled student as indicated in Exhibit A - Preliminary Submittals List. A copy of any material from the Operation and Maintenance Manual that is referenced by the training class shall be provided with each set of Student

Training Materials. The Student Training Manual shall include one unit for each objective of the Program. Each unit shall be arranged in seven sections that correspond and correlate with the first six sections of the Instructor Guides as indicated herein.

2. The first six sections shall match the first six sections of the Instructor Guide as follows.

    a. Section 1. - Title

    b. Section 2. - Time To Teach

    c. Section 3. - Objective

    d. Section 4. - References

    e. Section 5. - Equipment and Materials List

    f. Section 6. - Introduction

3. Section 7 - Presentation shall include all materials covered in the Instructor's Guide for the subject unit.

    a. The Student Manual shall be detailed enough to serve as a future reference document for the student.

    b. Include narrative descriptions of substation control scheme and circuit breaker interlock functions.

    c. All overhead transparencies and other visuals used in the class shall be reproduced in 8.5 by 11 inches' format in the Student Manuals. Such visuals shall either appear in the sequence presented, or be clearly referenced at that point in the text and located at the end of the text.

    d. Any demonstration equipment utilized in the lesson shall be represented by illustration of the equipment plus illustrations of any applicable details.

H. Staged Training Program

1. Training conducted at BART facilities or a location determined by the Engineer. Special power and supporting requirements shall be included in the Training Program Plan as indicated.

2. Training shall be divided into three sections: Basic training, advanced training, and refresher training.

3. Basic training shall consist of 120 hours of training and shall occur prior to commissioning of the first substation.

    a. There shall be 72 students total in basic training.

    b. There shall be approximately 12 students in each class, consisting of maintenance electricians, engineers, and one technical trainer.

    c. There shall be six classes.

d. Each class shall have duration of 20 hours.

4. Advanced training shall consist of 120 hours of training and shall occur within 60 days following commissioning of the first substation.

   a. There shall be 18 students total in advanced training.

   b. There shall be approximately six students in each class, consisting of maintenance staff, engineers, and one trainer.

   c. There shall be three classes.

   d. Each class shall have duration of 40 hours.

5. Refresher training shall occur every two years, and shall consist of two basic and one advanced class. Refresher training shall be provided at completion of each subsequent substation.

   a. There shall be 24 students total in basic refresher training.

   b. There shall be approximately 12 students in each basic refresher training class, consisting of maintenance electricians, engineers, and one technical trainer.

   c. There shall be 12 students total in advanced refresher training.

   d. There shall be approximately six students in each advanced class consisting of maintenance staff, engineers, and one trainer.

I. Deliverables

1. Deliverables shall include the Training Program Plan, the Instructor's Guides and Attachments, Student Training Materials, Staged Training Program Classes, and Final Deliverables.

2. Submit Final Training Deliverables following completion of the first 240 hours of basic and advanced training. The final deliverables shall consist of the following:

   a. Updated and corrected Instructor's Guides and Attachments.

   b. Updated and corrected Student Manuals in both hard copy and electronic files in Microsoft Word for Windows.

   c. Any models, mockups, simulations, classroom relay and PLC equipment, or other materials utilized to stage the Training Program.

3.26 CONSTRUCTION EQUIPMENT

A. The Contractor's on-track construction equipment shall be designed and constructed to operate within the dynamic envelope for District trains as specified in the BART Facilities Standards.

3.27 CONTRACT INTERFACES

A. Electric Utility Service Provider (Pacific Gas and Electric (PG&E))

1. Coordinate all utility requirements with PG&E and ensure that all the design and construction requirements of PG&E are complied with in the manufacture of the applicable electrical equipment and construction of subgrade structures/ ductbanks (associated with the incoming power sources) provided under the Contract.

2. PG&E's local distribution network is 21 kV and 12 kV, three-phase, 60 Hz. Additional technical data, such as fault levels, grounding requirements, and so forth, shall be obtained by the Contractor from PG&E, as needed.

3. Conform to PG&E's service requirements and the Contract.

4. In addition to coordinating with the PG&E, the Contractor shall be responsible for the following:

    a. Obtaining the necessary permits for the Work associated with the new and temporary power services from PG&E and the local authorities having jurisdiction.

    b. Complete the final design of the underground ductbanks and structures, transformer pads associated with the new incoming power services between the designated point of connection (to PG&E's distribution network) and the traction power facility(ies).

    c. Submit applications and request new power services at the traction power facilities as indicated in the Contract.

    d. Furnish and install underground ductbanks, structures and equipment pads, between PG&E's distribution network and traction power facility(ies).

    e. Furnish, install, test and commission the 21 kV or 12 kV/480V transformer and all cables between the PG&E's distribution network and the line side of the transformer at the traction power facility(ies).

    f. Furnish, install, test and commission all cables between the load side of the 21 kV or 12 kV/480V transformer and metering enclosure at the traction power facility(ies).

    g. Furnish and install the metering enclosure associated with the metering equipment; and all hardware and support equipment in the metering enclosure.

    h. Furnish, install, terminate and test the revenue metering equipment; associated CTs and PTs; and the low-voltage wirings and termination hardware.

    i. Coordinate the ductbank/utility pole interface with PG&E.

j. Ensure the Contractor-furnished equipment is mechanically and electrically compatible and complies with all requirements of PG&E.

k. Schedule inspections with PG&E and local authorities having jurisdiction (where applicable).

B. Third Party Utility Service Providers (for Water, Storm Water and Sewage)

1. Coordinate all utility requirements with the third-party utility service providers and ensure that all the design and construction requirements of the third-party utility service providers are complied with in the manufacture of the applicable components/materials and construction of subgrade structures/utilities (associated with the incoming water supply and, outgoing storm water and sewage connections) provided under the Contract.

2. Technical data shall be obtained by the Contractor from the respective third-party utility service providers, as needed.

3. Conform to third-party utility service provider's service requirements and the Contract.

4. The Contractor shall be responsible for the following:

a. Obtaining the necessary permits for the Work associated with the new and temporary power services from the third-party utility service providers and the local authorities having jurisdiction.

b. Complete the final design of the underground utilities and structures between the designated point of connection and the traction power facility.

c. Submit applications and request new services at the traction power facilities as indicated in the Contract.

d. Furnish and install underground utilities and structures between the third-party utility service provider's infrastructure and traction power facility.

e. Furnish, install, test and commission materials and components between the third-party utility service provider's infrastructures and the traction power facility.

f. Coordinate the interface requirements with third-party utility service providers.

g. Ensure the Contractor-furnished materials and components are mechanically compatible and complies with all requirements of the third-party utility service providers.

h. Schedule inspections with the third-party utility service providers and local authorities having jurisdiction (where applicable).

END OF SECTION 34 21 01

SECTION 34 21 05

PREFABRICATED AC AND DC EQUIPMENT HOUSES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Prefabricated AC and DC equipment houses including ancillary equipment.

B. Factory installation and acceptance testing of the fully equipped AC and DC houses.

C. Field Installation, verification, functional, and system integration testing of AC and DC houses.

1.02 RELATED SECTIONS

A. Refer to the following Sections for requirements:

1. Section 01 33 00 Submittal Procedures
2. Section 01 33 23 Shop Drawings, Product Data, and Samples
3. Section 01 43 00 Quality Assurance
4. Section 01 45 00 Quality Control
5. Section 01 45 24 Testing Program Requirements
6. Section 01 74 14 Cleaning
7. Section 01 77 00 Closeout Procedures
8. Section 01 78 23 Operation and Maintenance Data
9. Section 01 78 39 Project Record Documents
10. Section 01 78 44 Spare Parts and Maintenance Materials
11. Section 01 79 00 Demonstration and Training
12. Section 05 05 22 Metal Welding
13. Section 05 12 00 Structural Steel Framing
14. Section 05 40 00 Cold Formed Metal Framing
15. Section 07 81 16 Cementitious Fireproofing
16. Section 07 81 24 Intumescent Fireproofing
17. Section 08 71 00 Door Hardware

18. Section 08 90 00 Louvers
19. Section 10 40 00 Safety Specialties
20. Section 20 10 13 Common Materials and Methods for Facility Services - Fire Suppression, Plumbing and HVAC
21. Section 20 50 13 Raceways for Facility Services
22. Section 23 09 00 Instrumentation and Control for HVAC
23. Section 23 34 00 HVAC Fans
24. Section 23 81 00 Unitary HVAC Equipment
25. Section 26 05 17 Dry Type Transformers
26. Section 26 05 24 Low Voltage Wires and Cables
27. Section 26 24 24 Circuit Breakers and Panelboards
28. Section 26 50 00 Lighting and Electrical Power and Lighting General Criteria
29. Section 27 13 01 Communication Cables and Related Equipment
30. Section 27 30 01 Telephone Systems
31. Section 28 10 01 Access Control Systems
32. Section 28 31 00 Fire Detection and Alarm System
33. Section 28 41 29 Closed Circuit Television System
34. Section 34 21 01 Traction Power Facilities General Requirements
35. Section 34 21 18 AC Switchgear
36. Section 34 21 25 DC Switchgear
37. Section 34 21 28 Auxiliary Power Transformers (Dry Type)
38. Section 34 21 33 Control, Monitoring and Display Panel
39. Section 34 21 40 DC Control Power System
40. Section 34 21 50 Common Materials and Methods for Traction Power
41. Section 34 21 60 Grounding and Bonding of Traction Power Distribution
42. Section 34 21 70 Traction Power Facilities Installation Requirements
43. Section 34 21 75 Traction Power Facility System Factory Functional Testing
44. Section 34 21 80 Traction Power System Field Acceptance Testing

1.03 MEASUREMENT AND PAYMENT

A. Measurement: Prefabricated AC and/or DC equipment houses will be measured for payment per individual unit of house that is fabricated, factory tested, delivered to site, installed and field functioning tested in accordance with the Contract Documents.

B. Payment: AC and/or DC equipment houses will be paid for at the Contract unit price per each individual unit of house as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. American National Standards Institute (ANSI):

1. ANSI/NEMA C12.1 Electric Meters – Code for Electricity Metering
2. ANSI/ISEA Z358.1 Standard for Emergency Eyewash and Shower Equipment

B. American Society for Testing and Materials (ASTM):

1. ASTM E136 Fire Tests on Building Materials and Structures for Non-Combustibility Test
2. ASTM E84 Standard Test Method Burning Characteristics of Building Materials
3. ASTM B187/B187M Standard Specification for Copper, Bus Bar, Rod, and Shapes and General Purpose Rod, Bar, and Shapes

C. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):

1. ASHRAE Handbook of Fundamentals, Chapter 26
2. ASHRAE Publication SPCDX (Climate Data for Region X)
3. ASHRAE Guideline 16, Selecting Outdoor, Return, and Relief Dampers for Air-Side Economizer Systems
4. ASHRAE Guideline 24, Ventilation and Indoor Air Quality in Low-Rise Residential Buildings

D. California Department of Industrial Relations, Division of Occupational Safety and Health (Cal/OSHA) Regulations

E. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE C37.20.1 Metal-Enclosed Low Voltage (1,000 Vac and below, 3,200 Vdc and below) Power Circuit Breaker Switchgear

2. IEEE C37.20.1b — IEEE Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear – Amendment 2: Additional Requirements for Control and Auxiliary Power Wiring in DC Traction Power Switchgear
3. IEEE C37.20.2 — Metal Clad Switchgear
4. IEEE C57.96 — IEEE Guide for Loading Dry-Type Distribution and Power Transformers
5. IEEE 1653.4 — IEEE Standard for DC Traction Power System Field Testing and Acceptance Criteria for System Applications up to 1500 V DC Nominal
6. IEEE 1653.6 — IEEE Recommended Practice for Grounding of DC Equipment Enclosures in Traction Power Distribution Facilities

F. National Electrical Contractors Association (NECA):

1. NECA 301 — Standard for Installing and Testing Fiber Optic Cables
2. NECA NEIS 502 — Standard for Installing Industrial Lighting Systems

G. National Electrical Manufacturers Association (NEMA)

1. NEMA PB 1 — Panelboards

H. National Fire Protection Association (NFPA):

1. NFPA 70 — National Electrical Code
2. NFPA 72 — National Fire Alarm and Signaling Code
3. NFPA 101 — Life Safety Code
4. NFPA 130 — Standard for Fixed Guideway Transit and Passenger Rail Systems

I. Sheet Metal and Air Conditioning Contractor’s National Association (SMACNA):

1. Architectural Sheet Metal Manual – SMACNA

J. Underwriters Laboratories Inc. (UL):

1. UL 50 — Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations
2. UL 67 — Standard for Safety Panelboards
3. UL 489 — Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures

1.05 CODES AND REGULATORY REQUIREMENTS

Comply with the following codes and regulatory requirements:

A. Title 8, Section 5162 Emergency Eyewash and Shower Equipment

B. Title 24, Part 2 California Building Code

C. Title 24, Part 3 California Electrical Code

D. Title 24, Part 4 California Mechanical Code

E. Title 24, Part 6 California Energy Code

F. Title 24, Part 11 Green Building Standards Code

G. IEEE NESC National Electrical Safety Code (NESC)

H. American with Disabilities Act (ADA)

1.06 SUBMITTALS

A. Refer to the following Sections for additional requirements:

1. Section 01 33 00, Submittal Procedures
2. Section 01 33 23, Shop Drawings, Product Data and Samples
3. Section 01 78 23, Operation and Maintenance Data
4. Section 01 79 00, Demonstration and Training

B. Submit the following documents for equipment and materials as indicated.

1. Certificates from equipment vendors verifying that equipment conforms to specified requirements
2. Certification of equipment houses two-hour fire rating
3. Material Safety Data Sheets (MSDS)
4. Powder coating and painting process details
5. Design Drawings showing house dimensions, structural and anchoring details, equipment layout, floor plan and cutouts for conduits, personnel and equipment doors and associated hardware, and elevation views of all walls from the outside and inside, with all wall mounted equipment drawn to scale
6. Installation Manuals and Drawings

    a. Installation manuals shall include, but not be limited to the following:

1) A table of contents that shall identify all pages of the manual by revision and date.
2) Installation practices and procedures that the Contractor plans to use to accomplish the installation of the AC and DC equipment houses.
3) A list of installation drawings by number, revision, title and approval status and a copy of each drawing reduced to B size (11 by 17 inches).
4) Quality control procedures associated with the transportation and installation of the AC and DC equipment houses.
5) Installation verification procedures and data sheets.
6) Staging and implementation plans.

b. Installation Manuals shall reflect all the field modifications.

7. Heat load and heat exchange calculations showing that HVAC equipment can maintain house ambient temperatures within specified limits and in compliance to Title 24, Part 6, California Energy Code and Title 24, Part 4, California Mechanical Code.

   Heating and cooling design loads shall be determined in accordance with one of the procedures described in ASHRAE Handbook of Fundamentals. Calculations shall cover all aspects of the HVAC system design and shall include heating and cooling load calculations, system capacity calculations, system pressure drop calculations, noise calculations, and equipment selections. Computer programs shall be preferred for design calculations. Capacity of HVAC equipment shall be not less than 110 percent of calculated capacity, if heating or cooling equipment with the required capacities is not available the heating capacity or cooling capacity may be increased to a maximum of 130 percent of design loads, or as limited by requirements of the CCR Title 24, Part 6, California Energy Code.

8. Structural Calculations: Refer to Contract Specifications Section 34 21 01, General Requirements for the Traction Power System for requirements.

9. Lighting Calculations for the interior spaces and exterior areas of the traction power facility.

10. Certification, to be reviewed and approved by a District appointed independent testing agency, that exterior powder coating system is a two-step process and provides five mils minimum thick weather-resistant finish on all exterior surfaces and is applied in accordance with the application instructions.

11. Certification of floor resistance to 2,500 DC circuit breaker racking operations.

12. Installation verification and field functional test documentation including procedures, data sheets, and reports per Contracts Specification Section 34 21 80, Traction Power System Field Acceptance Testing.

13. System functional test documentation including procedures, data sheets, and reports per Contracts Specification Section 34 21 80, Traction Power System Field Acceptance Testing.

14. List of recommended spare parts in accordance with Contract Specifications Section 01 78 44, Spare Parts and Maintenance Materials.

15. Operation and Maintenance manuals in accordance with Contract Specifications Section 01 78 23, Operation and Maintenance Data.

16. Training materials in accordance with Contract Specifications Section 01 79 00, Demonstration and Training.

17. Warranty Certification.

C. Submit samples of the following:

1. Equipment electrical and thermal insulation materials, their physical and electrical properties, and proposed methods of installation.

2. Indoor and outdoor finishes, including certification that exterior finish is graffiti and ultra-violet (UV) resistant.

3. Weatherstripping, including certification that exterior finish is graffiti and ultra-violet (UV) resistant.

1.07 QUALITY CONTROL, QUALITY ASSURANCE, AND SUPPLIER QUALIFICATIONS

A. Refer to Contract Specifications Section 01 43 00, Quality Assurance and Section 01 45 00, Quality Control, for hardware quality assurance requirements.

B. Manufacturer Qualifications:

1. Products shall be manufactured by firms regularly engaged in manufacturing products described in this Section.

2. Factory testing shall be performed by persons having five or more years of verifiable and relevant testing experience.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Refer to Article 1.07 in Section 34 21 70, Traction Power Facilities Installation Requirements, for requirements.

B. Inspect AC and DC equipment houses prior to shipment and obtain appropriate certification in accordance with the requirements of the State of California related to oversize and overweight loads and other requirements as applicable.

C. Coordinate and schedule with the applicable authorities to obtain the appropriate permits and highway and roadway transportation clearances to haul the AC and DC equipment houses to the Jobsite or to park vehicles with the AC and DC equipment houses along the public right-of-way.

D. Prapare complete AC to DC equipment houses for transport by securing or removal of all loose items.

E. Remove and separately package interior and exterior components which are likely to be damaged in transport due to vibration, lifting, and bumping, and other movements.

F. Disconnect and remove battery cells and pack and secure in a pan for transport.

G. Use approved spreader bar for lifting so as not to damage form, fit, or finish of equipment.

H. Equipment shall be weatherproofed for shipment. Connection openings shall be closed to prevent entrance of moisture and any foreign material during shipment and storage.

I. Equipment shall be handled and stored in conformance with manufacturer's instructions. One copy of these instructions shall be included with the equipment at time of shipment.

J. Coordinate and schedule with the applicable third party utility service provider(s) to electrically isolate or temporarily disconnect overhead utilities (where they obstruct the pathway) along the planned haulage route to the Jobsite.

K. Utilize the services of an experienced and fully bonded rigging contractor to perform lifting and transport of AC and DC equipment houses.

L. Replace damaged houses, enclosures, switchgear, equipment, wirings, terminations and components during transport at no cost to District.

1.09 WARRANTY

A. Warrant AC and DC houses to be free from defective materials and workmanship, water leakage and seepage, and condensation. The warranty shall be signed by the Contractor agreeing to correct system deficiencies and replace components that fail in materials or workmanship. The warranty shall be for the period between installation and the start of revenue service, and for a five year period from the date of acceptance of the AC or DC houses by the District.

1.10 GENERAL REQUIREMENTS FOR THE TRACTION POWER SYSTEM

A. Refer to Contract Specifications Section 34 21 01, General Requirements for the Traction Power System, for requirements.

PART 2 – PRODUCTS

2.01 GENERAL

A. AC and DC equipment houses and their associated equipment shall be in separate houses.

B. AC and DC equipment houses shall be prefabricated, climatized, self-supporting, and transportable. The houses shall be weathertight and be free from defective materials and workmanship, water leakage and seepage, and condensation.

C. The outside height of the AC and DC equipment houses shall not exceed 12 feet, six inches or the height constraints imposed by the respective Department of Transportations through which the AC and DC equipment houses will be transported to the testing facilities and/or Jobsite.

D. Completed AC and DC equipment houses shall be UL labeled and have a two-hour fire rating.

E. Aisle arrangements shall be designed for optimal personnel safety, adherence to NFPA 70 and other industry codes and standards, and standard operating and maintenance procedures within the District.

F. Unless approved by the District, do not mount equipment, conduit or wireways to the removable panels in the DC equipment houses.

G. Placement of equipment or raceway shall not obstruct access, maintenance, or ability to replace any other equipment in the house.

H. Placement of cooling fans in equipment enclosures shall avoid obstructions in air flow when enclosure doors are open and/or closed.

I. Provide horizontal and vertical clearances, as prescribed by industry standards, between enclosures and components housed within enclosures.

J. Equipment, enclosures or boxes, components, conduit, cables, conductors and fiber optic strands shall be identified and labeled per the Contract Drawings and approved vendor design documents.

K. Fire damper at the battery room, within the DC equipment house, shall include auxiliary contacts to interface to the SCADA system.

L. Lighting Calculations:

1. In each case provide a lighting calculation of illuminance maintained on a horizontal plane, unless otherwise required herein.

2. Display the results in footcandles, considering the light loss factors, in accordance with standard engineering practice.

3. Take the horizontal plane at finished floor or finish grade at all locations.

4. Use a calculation grid of two feet by two feet for areas up to 40 feet on a side. For larger areas use a calculation grid no greater than five feet by five feet.

5. On the calculation sheet, show a lighting fixture schedule (luminaire schedule) that includes for each fixture its symbol, quantity, label, arrangement (single or double), lumens, light loss factors, and description.

6. Show a calculation summary including the calculation type, units, average maximum, minimum, ratio of average to minimum, and ratio of maximum to minimum. Show the fixture mounting details, locations and mounting heights on the plan drawings for interior and exterior lighting, and show the surface reflectances and illumination levels.

7. Minimum lighting levels shall be maintained when all equipment doors are opened.

2.02 HOUSE ASSEMBLIES

A. General:

1. The AC and DC equipment house frames shall utilize steel post-and-beam framing with roof purlins.

2. AC and DC equipment houses shall be designed for the applicable building code live loads and lateral loads and the following additional design requirements:

   a. In addition to roof live load of minimum of two people, design roof-supporting members to support cable trays and any other equipment that is hanging from the roof. As a minimum, this load shall be 15 pounds per square foot.

   b. In addition to the supported equipment, design floor for a uniform live load of 100 pounds per square foot or a concentrated load of 1,000 pounds, applied anywhere and distributed over an area of one foot square.

   c. Provide additional structural supports and roof beams at the shipping splits such that each shipping section is a self-supporting structure.

3. Form joints, locks and seams, interior and exterior, between panels of wall, floor and roof in accordance with the SMACNA Architectural Sheet Metal Manual, Figures 3-2 and 3-3, Locks and Seams Design Data or equivalent water-tight joints as approved. Seal joints with non-hardening compound suitable for indoor and outdoor applications to be compatible with metal finish as recommended by sealant manufacturer.

4. House splits and base structures shall be electrically bonded.

5. Provide separate battery area from the remainder of the dc equipment house with a partition wall including two doors and floor drain, as indicated. The wall shall be full height extending to the ceiling. Provide exhaust fan on the exterior wall near the ceiling and air intake on an opposing exterior wall near the floor. Provide eyewash as specified herein.

B. Base Structure:

1. The base of the house shall be structural steel meeting requirements of Specifications Section 05 12 00, Structural Steel Framing:

   a. The main, cross, and longitudinal tie members shall consist of structural steel channels, angles, and beams sized as required and braced and joined between shipping splits to provide adequate strength for installation and for operation.

   b. The base channels shall be suitable for welding to leveling channels embedded in concrete.

2. Provide lifting lugs on the base of each complete shipping section. Design base structure for each shipping section to provide adequate strength for lifting. Other components of the house shall not be permitted for lifting.

3. Fire proof the underside of the base structure in accordance with Contract Specifications Section 07 81 16, Cementitious Fireproofing, or Contract Specifications Section 07 81 24, Intumescent Fireproofing, whichever is most appropriate.

C. Floor Plate:

1. Floor: Wall-to-wall steel plate, designed to accommodate the layout as indicated and welded to the main, cross and tie channels. Determine thickness of the steel plate based on the floor loading. Minimum plate thickness shall be 1/4-inch.

2. Dielectric insulating floor for DC equipment houses: The floor for DC equipment houses shall be covered with dielectric insulating material (flooring) complying with the following requirements. Install in accordance with insulating material manufacturer’s written instructions.

   a. Material: Pourable non-hygroscopic insulating material, based on epoxy compound with a non-asbestos filler, Amazite or equal. Thickness shall not be less than 1/4-inch. Final floor surface shall be uniform, level, slip-resistant. Allowed variation shall be less than 1/16-inch.

   b. The floor insulation shall not crack under the anticipated mechanical and thermal stresses during the 40-year life cycle of the house. Submit certification that floor has withstood the equivalent 2,500 operations of circuit breaker withdrawal and replacement with no degradation of floor surface.

   c. Minimum dielectric strength of the insulating material shall not be less than 250 volts/mil. Surface resistance measured with a 5,000V megger using a six-inch square (minimum) weighted test plate with meter connected between the test plate and the DC house structure ground shall exceed 1,000 megohms.

   d. DC equipment enclosures shall be mounted on the floor through insulating fasteners of sufficient dielectric and mechanical strength.

3. Provide floor openings as required. Design floor openings to provide access to cable vaults below and routing, internal to the house, to grounding pigtails, as indicated. Provide exposed floor openings with electrically insulated covers to withstand equipment weight and traffic. Furnish covers with lifting handles. Floor openings for cable penetration to the switchgear shall have smooth edges to avoid damaging the cables.

4. Provide floor for battery area with a containment to retain any electrolyte spill. Place a durable electrolyte-resistant plastic mat on the floor to protect the floor and the curb from electrolyte. Containment area shall be able to hold electrolyte from two battery cells.

5. For AC equipment houses, the covers for the floor opening to the 34.5 kV trench below shall be non-ferrous. The covers for the floor opening in the 34.5 kV switchgear cable compartment shall have holes. Number and location of openings shall be determined and oriented per the required cable training and termination. The covers shall be split with the split running through the centerline of the holes. After cable and cover installation, the split and holes shall be vermin-proofed.

D. Wall Assembly:

1. Walls shall be of double panel construction. Fabricate wall panels from cold-rolled or formed sheet steel meeting requirements of Specifications Section 05 40 00, Cold Formed Metal Framing as follows:

   a. Outer wall panels: No. 14 gage minimum

   b. Inner wall panels: No. 16 gage minimum

2. Wall panels shall be 24-inch modules or manufacturer’s standard and shall be bolted at mating flanges to maintain even tension on the panel skin, adding strength, and providing a smooth appearance.

3. Provide wall openings as required. Locate cross and longitudinal tie channels such that no loss of structural integrity is caused by these openings.

4. Interior walls, associated with the battery room shall be of similar construction to the exterior walls and shall totally enclose the battery room area.

5. Where the AC busway or conduits (serving the battery room) are routed through the battery room, seal around the wall penetrations to maintain an equivalent barrier as the wall. Unless approved by the District, do not route infrastructure through the battery room.

6. The design shall permit removal of major equipment such as switchgear cubicles and rectifiers from the houses. Removable wall panels are acceptable for this purpose.

E. Roof Assembly:

1. The roof shall be of the gable type with a slope of one in 12 or flat roof with uniform two percent slope. Rain caps shall be provided over adjacent panels to adequately drain water. Rain caps shall be overlapping inverted V, large enough to divert two inches of rain per hour.

2. Roof assembly shall consist of exterior load-carrying panel members and a false interior ceiling. Assembly shall allow for expansion and contraction and be watertight.

3. The outer roof panels shall be a flat seam or standing seam design, fabricated from the same material as the outer wall panels. Form and flash seams, splices and roof penetrations in accordance with the SMACNA Manual, Seventh Edition. Provide per reference figures from the Architectural Sheet Metal Manual as follows:

   a. Provide expansion batten seams perpendicular to the roof ridge and at connections of shipping splits. Sections between seams shall not exceed 30 feet in any direction. Form expansion batten seams as shown in Figure 6-8, Detail 1, Batten Seam Roofs.

   b. Form eaves at expansion batten seams as shown in Figures 5-1, Building Expansion Joints and 5-2, Expansion Joint Intersection.

   c. Flash seams parallel to the roof ridge as shown in Figure 6-6, Standing Seam Roofs, Detail 3 or Figure 6-17, Vented and Non-Vented Ridge Caps.

   d. Flash ridge as shown in Figure 6-6, Standing Seam Roofs, Detail 5 or Figure 6-17, Vented and Non-Vented Ridge Caps.

   e. Flash roof penetrations as shown in Figures 8-1, 8-2, 8-3, Roof Penetration Panel(s), 8-9, Roof Penetration Flashing-Pipes, and 8-10, Roof Penetration Flashing-Structural Steel.

4. Fabricate inner ceiling panels from the same material as the inner wall panels, and install to the underside of the roof assembly.

5. Roof assembly shall provide double ceiling panels, with adequate space between panels and, between upper panel and house roof, to accommodate two thermal insulation layers.

6. Roof shall be coated with a solar reflective coating with the following minimum characteristics in accordance with Green Building Standards Code (Cal Green) Non-residential Voluntary Measures:

   a. Maximum three-year solar reflectance greater than or equal to 0.55.

   b. Thermal emittance greater than or equal to 0.75.

2.03 FACTORY INSTALLATION AND ASSEMBLUY

A. Fabricate each AC and DC equipment house as a complete equipment house, with all equipment, devices, accessories and appurtenances in place for a fully functioning and operable equipment house.

B. Install, wire, calibrate, and test, as a unit, all AC and DC house equipment specified to be mounted in the AC and DC equipment house enclosure.

C. Components shall be mounted in accordance with the Contract requirements, manufacturers' instructions and the approved equipment vendor designs.

D. Install equipment secure, level, plumb and in true alignment with related adjoining work.

E. The installation of the electrical insulation shall not obstruct the operation of equipment and opening/closing of enclosure and cubicle doors.

F. Configuration of equipment and conduit installations shall not block access to any other equipment and shall allow easy access to and replacement of all house equipment and components.

G. The design of the shipping splits and interconnection enclosures shall:

1. Not obstruct the operation of equipment or opening/closing of enclosure and cubicle doors.

2. Not physically make contact with DC switchgear cubicles and/or rectifier enclosures.

H. Finished floor, within the AC and DC equipment houses, shall be flat and have no raised spots.

I. Enclosure and cubicle doors shall operate per the design intent without hitting adjacent structures or equipment.

J. Penetrations of exterior walls shall be covered and sealed in accordance with the equipment vendor's recommendations to ensure the integrity of the exterior walls within the specified environmental conditions and prevent water ingress.

K. Unless otherwise recommended by the equipment vendor, attach glastic type insulation to equipment enclosures, walls, etc. with insulated hardware.

L. Where spare circuit breaker cubicles are indicated on the Contract Drawings, provide complete and fully functional cubicles, extend buses into the cubicles, provide cable entrance and, provide power, control and indication circuits except without circuit breakers.

M. Provide at least two - 750 kcmil ground conductors between ground and the NGD negative bus, individually routed in dedicated conduits for connection to the NGD. Cables shall be routed to two different physically separated ground connection points. Coordinate with the ground grid design.

N. Coordinate equipment spatial and placement of power, communications and grounding requirements with the respective equipment vendors.

O. Locate 125 V DC battery system's fused disconnect switch within the battery room.

P. Factory installed cables, conductors and jumpers shall be in overhead and riser conduits, wireways and/or cable trays.

Q. Structured wire management system shall be implemented for all factory installed cables, conductors and fiber optic strands. Refer to Contract Specifications Section 34 21 01, General Requirements for the Traction Power System, for additional requirements.

R. Overhead light fixtures, conduits, wireways and cable trays shall be mounted to the AC and DC equipment house structure in accordance with the approved equipment vendor seismic design.

S. Unused enclosure/box openings shall be sealed.

T. Openings in enclosures shall be fitted with grommets or equivalent to prevent damage to cables and/or conductors.

U. Complete the installation and cleaning of conduits, wireways and cable trays (inclusive of mounting hardware) before starting wire/cable installation in accordance with Contract Specifications Section 20 50 13, Raceways for Facility Services, and BART Standard Drawing TPS76.

V. Factory installed cables, conductors, fiber strands and jumpers shall be installed as specified herein, and in accordance with Contract Specifications Section 34 21 50, Common Materials and Methods for Traction Power, per the equipment vendor requirements, and other requirements specified elsewhere in the Contract.

W. Circuits associated with the Fire Detection and Alarm System shall be routed in dedicated conduit and boxes.

X. Fiber optic cables run within buildings shall be routed in dedicated wireways, conduits, and boxes. This requirement also applies to fiber optic cables entering from outside of house which terminate at equipment inside the house.

Y. Provide common wireways segmented in three sections, for power, control, and communications cables. Fiber optic cables may be accommodated in a segmented wireway with power and control cables installed in adjacent segments.

Z. Provide two 125 V DC control power branch circuits (from separate circuit breakers) to each AC switchgear line-up and each DC switchgear line-up to provide control power to the 125 V DC control bus and to the breaker test cabinet for circuit breaker operation and for control equipment operation. Refer to Contract Specifications Section 34 21 18, AC Switchgear, and Contract Specifications Section 34 21 25, DC Switchgear, for 125 V DC control bus, circuit breaker and wiring requirements within the cubicles.

AA. Provide dedicated LV control power branch circuit(s) to each piece of SCADA processing equipment, CO2's HMI, communications switching equipment and the fiber optic transceivers/media converters.

BB. The following information shall be identified on equipment access doors (AC equipment house), AC switchgear cubicle doors (front), and DC switchgear cubicles (front and rear) in accordance with the approved equipment vendor design:

1. Circuit breaker/auxiliary cubicle designation.

2. Unit designation.

3. Circuit breaker description.

CC. All three phase LV circuits shall be phase tapped in accordance with the color coding requirements specified in Contract Specifications Section 26 05 24, Low Voltage Wires and Cables.

DD. Install grounding connections to the ground test stations per the approved equipment vendor designs, and in accordance with Contract Specifications Section 34 21 60, Grounding and Bonding for Traction Power Facilities.

EE. Enclosure/cubicle ground and/or bonding straps shall be of sufficient length to permit doors to operate per design intent yet not be pinched or subject to mechanical damage.

FF. Interconnect all indication functions specified herein to the C02 cabinet for local and remote operation/monitoring in accordance with Contract Specifications Section 34 21 33, Control, Monitoring and Display Panel.

GG. Refer to Contract Specifications Section 34 21 01, General Requirements for the Traction Power System, for additional requirements.

2.04 DOORS AND REMOVABLE PANELS

A. General (Doors - Entry, Equipment Access and Battery Room)

1. Doors shall swing out. Doors, except the battery room, shall have a heavy-duty door stop to hold the door in the open position. Door stop/hold unit shall hold the door in a fully opened (180 degrees for entry and equipment access). Battery room door shall open at least 90 degrees.

2. Provide weatherstripping and flashing. Weatherstipping shall be ultra-violet (UV) resistant.

3. Provide braided ground strap, 1/2 inch x 14 inches tinned plated copper with 1/4 inch x 1/2-inch stainless steel bolts and nuts installed near the top door hinge for bonding the door to the house frame. Strap shall be installed on the interior side of the door and the installation shall assure sufficient contact.

4. Provide two pairs of 4-1/2 x 4-1/2 inches, five-knuckle, concealed bearing, stainless steel hinges with non-removable pins.

5. The design of exterior walls shall include a continuous drip shield extending out by at least four inches, caulked at interface to exterior wall, located above each entry and equipment access door.

6. Exterior hardware shall be stainless steel.

7. The design of equipment access doors shall include louvers with a filtration system that does not require the door to be opened when the filters need to be changed. Changing filters shall not compromise the NEMA 3R rating.

B. Entry Doors: Provide entry doors as indicated and as specified herein:

1. Single doors size: 42 inches minimum by 96 inches.

2. Double doors size: Two x 36 inches by 96 inches.

3. House doors shall be keyed and shall have heavy-duty exit devices. The main entry door of each house shall have a card reader access control via a card reader system.

4. The door for equipment removal shall be matched with adequately sized landing pad outside, level with the interior door, to facilitate loading and unloading of equipment.

5. Door Construction: Fabricate doors and frames of formed sheet steel, 16 gauge minimum, galvanized and shop primed, reinforced to support door closer and panic hardware. Insulate doors. Manufacturer’s standard thermal insulation may be acceptable in lieu of the specified insulation subject to District approval. Double doors and frames exceeding 72 inches wide shall be 14-gauge minimum.

6. Entry doors shall be weatherproofed.

7. Door hardware for each door shall comply with Contract Specifications Section 28 10 01 Access Control Systems.

8. Provide a metal awning for rain protection over all entry doors and equipment outdoor access doors. Awnings shall protrude a minimum of 18 inches and shall slope away from the building so that rainwater drains away from the door.

C. Battery Room Doors (DC Equipment Houses): Provide battery room doors as indicated and as specified herein:

1. Battery room design shall include an exterior doorway permitting access to the battery room without accessing the DC equipment house and an interior doorway permitting access from within the DC equipment house.

2. Battery room exterior door shall have the same characteristics and use same hardware as other house single entry doors.

3. Single Door Size: 42 inches minimum by 96 inches.

4. Door Construction: Fabricate doors and frames of formed sheet steel, 16 gauge minimum, galvanized and shop primed, reinforced to support door closer and door hardware.

5. Door hardware for each door shall consist of operating handles located at working height referenced to actual finished floor surface.

6. Unless provided in the battery room interior wall, the interior door design shall include a mechanical fire damper (located in the lower half of the door) that shall automatically close during a fire incident.

D. Equipment Access Doors (AC Equipment House): Provide equipment access doors as indicated and as specified herein:

1. Exterior equipment access doors shall be provided at the rear of switchgear cubicles, to facilitate termination of 35 kV cables and equipment maintenance.

2. Fabricate equipment access doors and frames of formed sheet steel, 16 gauge minimum, galvanized and shop primed, reinforced to support door closer. Doors and frames exceeding 72 inches wide shall be 14-gauge minimum.

3. Equipment access doors shall be weatherproof.

4. Each equipment access door shall be provided with an outdoor type padlock, with all padlocks keyed alike.

5. Exterior equipment access doors shall have padlockable operating handles located at working height referenced to actual final ground elevation at site.

E. Removable Panels (DC Equipment House): Provide removable panels in line with each rectifier as indicated and as specified herein

1. Panel Size: Size panels doors to allow for the removal of the rectifier units (without dis-assembly).

2. Panel Construction: Fabricate removable panels and frames of formed sheet steel, 16 gauge minimum, galvanized and shop primed, reinforced. Install and insulate panels similarly to the permanent exterior walls.

3. Removable panels shall be weatherproof.

4. Provide supplemental header structural supports to maintain seismic design of the DC equipment house.

5. Secure panels to the exterior walls with tamper resistance stainless steel fasteners.

6. Alternative placement of removable panels shall be submitted for review and approval by the District.

F. Equipment Access Doors (DC Equipment House):

1. As an alternative to removable panels, equipment access doors sized to allow for the removal of the rectifier units (without dis-assembly) can be proposed by the Contractor for consideration and approval by the District.

2. Door construction shall comply with the requirements specified above for equipment access doors.

2.05 WEATHERPROOFING

A. AC and DC equipment houses shall have a NEMA 3R minimum rating.

B. Doors, removable panels, joints, walls, roofs, floors, vents, louvers and outdoor accessories shall be weatherproofed under the wind, rain and weather conditions specified in Contract Specifications Section 34 21 01, General Requirements for the Traction Power System.

C. Provide weatherstripping and flashing for openings such as doors and removable panels to exclude water entry under all weather conditions.

D. Penetrations into the enclosure shall have weather-proof and fire-proof caulking.

2.06 FINISHES

A. Exterior surfaces, including roof and ventilating domes, shall be finished as noted below:

1. Enclosure finish shall be treated with a galvannealed coating and finished with a powder coat.

2. The galvannealing coating process shall be a two-step coating process with the following characteristics:

a. Lower coating shall be ten percent iron-zinc alloy deposited by the hot-dip process

b. Lower coating weight: 60 g/m^2, minimum

c. Upper coating shall be 80 percent iron-zinc alloy electroplated deposited by the hot-dip process

d. Upper coating weight: three g/m^2, minimum

e. Corrosion resistant capabilities: Maximum 1/8-inch creep corrosion when vertically scribed and exposed to five percent salt fog per ASTM B117 for 1,500 hours.

3. The powder coating process shall be a two-step process with the following characteristics:

a. Thickness: five mils, minimum

b. Color:

1) Powder coat: Medium beige, Sherwin Williams (#PLT6-1S4) or equal.

2) Wet paint color: Sherwin Williams #F63RXN28022-4337 POLANE S or equal.

3) Aerosol can: Sherwin Williams #J22XXN28029-4337 or equal.

c. Weather, graffiti, and ultra-violet (UV) resistant

d. Following house assembly any areas exposed to the outside atmosphere that have been affected by cutting or welding, shall be spot galvanized with a primer that forms a dry film no less than 90 percent pure zinc. Touch-up paint shall be applied to match the powder coat finish.

B. Provide minimum of 20 Working Days' notice prior to fabrication of house exterior panels for BART inspection and independent assessment of finish characteristics to determine specification compliance. Finish characteristics shall be confirmed by the BART independent inspection prior to commencement of house construction.

C. Surfaces of equipment inside the AC and DC equipment houses shall have an ANSI 61 gray finish, in accordance with Contract Specifications Section 34 21 01, General Requirements for the Traction Power System, with a minimum thickness of two mils.

D. Following assembly, any areas exposed to outside atmosphere that have been affected by cutting or welding shall be spot galvanized with a primer that forms a dry film of no less than 90 percent pure zinc.

E. Painted AC and DC houses, and equipment enclosures that do not meet the specified requirements shall be repainted at no cost to the District.

2.07 THERMAL AND ACOUSTICAL INSULATION

A. General

1. Insulating materials shall have a certified classification of non-combustible as defined by ASTM E136. Flame proofing of insulating materials will not be acceptable and proof of certification shall be by one of the following:

a. UL label or listing

b. National Bureau of Standards test results

c. Certified test report from a nationally recognized testing laboratory

B. Thermal Insulation

1. Floor Insulation: Coated, glass-fiber insulation, one inch thick, three pounds per cubic foot (pcf) minimum density, applied with adhesive and mechanical fasteners to underside of floor plate.

2. Wall, Roof and Access Door Insulation: Foil faced glass-fiber, two inches thick, three pcf minimum density with foil face facing interior, sandwiched between the inner and outer panels.

3. Minimum rating of thermal insulation shall be R-21 (U-0.048) for walls and R-38 for ceilings per Title 24, Part 2 (CBC).

C. Acoustical Insulation

D. Acoustical insulation may be used to limit the maximum allowable continuous noise level produced by the equipment inside of AC and/or DC equipment house. Refer to Contract Specifications Section 34 21 01, General Requirements for the Traction Power System, for noise level constraints.

2.08 HEATING, VENTILATING AND AIR CONDITIONING

A. General

1. The AC system or HVAC system shall conform to the design requirements of ASHRAE standards and Title 24 (California Energy Code and California Mechanical Code).

2. The design of the AC or HVAC shall include a control scheme, which when activated by the Fire Detection and Alarm System shall de-energize the HVAC units and annunciate an alarm locally (at the CO2's HMI) and remotely (at OCC).

3. The AC System or HVAC system shall provide a positive pressure system within the AC equipment houses and DC equipment houses (battery room excluded).

B. Design Criteria

1. Indoor and Outdoor Design Conditions

a. Indoor temperature shall not exceed 85 degrees Fahrenheit (29 degrees Celsius) summer maximum temperature for normal (unoccupied) mode of operation. The HVAC system shall be capable of providing 72 degrees Fahrenheit (22 degrees Celsius), with HVAC equipment operating at its design capacity, during times when the house is occupied. Summer outdoor temperature shall be as specified by Title 24, Climatic Data for the region in which the house is to be located.

b. The HVAC system shall have a timed override option which allows the occupied mode to be initiated and then when it times out the HVAC system shall revert to the normal mode. AC and DC houses shall be positive pressured with 0.5 air changes per hour exfiltration combined with air transferred out.

c. Indoor temperature shall not drop below 60 degrees Fahrenheit (15 degrees Celsius). Winter outdoor temperature shall be as specified by Title 24, Climatic Data for the region in which the house is to be located.

d. Space relative humidity shall not exceed 55 percent.

e. Air conditioning or HVAC equipment shall function as a closed system or maintain positive pressure in the house.

f. The system shall have the ability to maintain all specified climate conditions when one HVAC unit is out of service.

g. Provide capability for local and remote monitoring of the HVAC equipment.

2. Indoor Heat Rate: Indoor heat rate gains shall include heat-generating equipment and components based on their design loading. Provide a minimum of two HVAC units. Design calculation shall assume one unit to be out of service.

3. Transmission/Solar Heat Gains: Transmission heat gains through sunlit walls and roof shall be based on CLTD method in accordance with ASHRAE Handbook of Fundamentals, Chapter 26. Assume medium color roof and walls, outdoor temperature as specified in Article 2. 07B.1.a herein, and long axis oriented in the East-West direction. No credit shall be taken for heat outflow from the enclosure.

4. Noise Criteria: Noise generated by the operating AC or HVAC equipment shall not exceed 55dB at any point along a perimeter ten feet away from the exterior outline of the enclosure.

C. Louvers: Louvers shall be in accordance with Section 08 90 00, Louvers and per contract documents.

D. Heating and Ventilation Equipment: Refer to Contract Specifications Section 23 34 00, HVAC Fans, and Contract Specifications Section 23 81 00, Unitary HVAC Equipment, for heating, cooling and ventilation equipment requirements.

E. Submit heat load and heat exchange calculations showing the AC system or the HVAC system can maintain the required indoor climate conditions.

Heating and cooling design loads shall be determined in accordance with one of the procedures described in ASHRAE Handbook of Fundamentals. Calculations shall cover all aspects of the HVAC system design and shall include heating and cooling load calculations, system capacity calculations, system pressure drop calculations, noise calculations, and equipment selections. Computer programs shall be preferred for design calculations. Capacity of HVAC equipment shall be not less than 110 percent of calculated capacity, if heating or cooling equipment with the required capacities is not available the heating capacity or cooling capacity may be increased to a maximum of 130 percent of design loads, or as limited by requirements of the CCR Title 24, Part 6, California Energy Code.

F. Battery Room

1. Provide ventilated exhaust system with negative pressure in accordance with Title 24, Part 4, California Mechanical Code. Exhaust ducts from battery rooms shall not connect with duct systems used for other purposes. Battery room exhausts shall be ducted to the exterior of the building. The output from the exhaust shall not be vented to general public areas.

2. Provide a hydrogen sulfide (H_2S) detector directly above batteries. Upon detection of a 1 percent H_2S air concentration start the battery room exhaust fan, and upon detection of a 2 percent H_2S air concentration discontinue battery charging and initiate a local alarm at the C02 control panel and remote alarm at OCC.

3. Provide hood at exterior of battery fan exhaust to direct exhaust downward. Provide gravity louvers.

2.09 EMERGENCY EYEWASH AND DRAINAGE

1. Provide permanent eyewash, in accordance with Cal/OSHA/ANSI/ISEA Z358.1, connected to a hardlined water source in the battery room of the DC equipment house as per contract documents.

2. Provide floor drain in accordance with Federal, State, and local ordinances in the battery room of the DC equipment house which drains to sewer line. Drainage to appropriately sized drywell may be used with Engineer's approval.

2.10 ELECTRICAL WORK

A. Lighting

1. General

   a. Locate light fixtures to avoid interference with overhead raceways or other major wiring or blocking of the light. Do not place light fixtures directly above equipment.

   b. Emergency light fixtures shall be wired un-switched.

   c. Normal lighting levels shall meet the following minimums, measured at floor level within the AC and DC equipment houses and at finished grade level:

      1) Aisle - 50 footcandles, average, maintained

      2) Outdoor - five footcandles, average, maintained around doorway.

   d. Emergency lighting levels shall be at least five footcandles (FC), average, at floor level within the AC and DC equipment houses. The minimum emergency lighting intensity shall be at least two FC at floor level within the AC and DC equipment houses and three FC on each exit door surface.

2. Provide LED lighting suspended at nine feet above finished floor in each house:

   a. Luminaires color shall be cool white.

   b. Provide fixtures with clear enclosures.

   c. Control interior lighting by surface-mounted three-way or four-way switches of industrial specification grade.

3. Provide emergency lighting with self-contained charger test switch and battery sized for 90-minute operation. Emergency lighting illumination level shall be a minimum of one FC at any point at the floor level and shall conform to NFPA 101.

4. Exterior lighting shall consist of a weatherproof, wall mounted area lighting fixture above each doorway. Fixture shall be a one-piece housing/refractor of polycarbonate. Photometrics shall provide a low glare, downward and outward light distribution. The exterior lighting shall be on a separate circuit, and shall be controlled by a switch with three-positions as follows: ON, OFF, and AUTO. In the AUTO position, the exterior lighting shall be controlled by a photoelectric cell.

5. Provide exit light fixture above each entry doorway on interior wall above doorway.

6. A permanent light fixture and switch shall be provided in the following equipment enclosures:

   a. AC Switchgear Breaker and Auxiliary Cubicles (front and rear)

   b. DC Switchgear Breaker and Auxiliary Cubicles (front & rear)

   c. Rectifier Transformer Control Panel (front)

   d. Rectifier (front and rear)

   e. Negative Grounding Device (front)

   f. C02, C03, and C04 Cabinets (front)

7. Light fixtures shall include clear enclosures.

B. Equipment Electrical Insulation

1. Provide equipment insulation as indicated and as specified herein.

2. Submit samples of equipment insulating materials, their physical and electrical properties, and proposed methods of installation.

3. Insulating materials, when exposed to flames or electrical arcing, shall not give off toxic gases or products of combustion which are harmful to personnel or to the surrounding equipment or which will result in electrical arcing.

4. Minimum clearance between high-resistance ground equipment enclosures and solidly-grounded equipment enclosures shall be eight feet, unless indicated otherwise.

5. Where clearance from any parts of high-resistance ground equipment to walls, columns, doors, equipment or any grounded object is less than eight feet, the walls, columns, doors, equipment or grounded object shall be insulated to a height of eight feet with an insulation sheet of glastic type rated at 1,500 volts DC minimum. Provide minimum glastic thickness of 1/8 inches.

6. No gaps shall exist between electrical wall insulation and the floor or between adjacent insulation sheets. No non-insulated fittings or hardware shall protrude through or be unprotected by insulation.

7. Wall insulation protecting exposed structural wall sections shall extend at least ten feet beyond the limits of the high-resistance ground equipment.

8. Floor insulation for the high resistance grounded equipment shall cover the entire floor.

9. Provide isolation between each dc switchgear cubicle and between rectifier and dc switchgear using non-conductive structural members, to provide a minimum one-inch isolation between adjacent sections.

10. Provide non-conductive isolating collar at connection between rectifier and AC bus duct. Grounded and HRG sides shall not be able to be bridged by a person.

C. Cabling/Wiring

1. Cables and wires shall be as specified in Contract Specifications Section 34 21 50, Common Materials and Methods for Traction Power and in Contract Specifications Section 28 31 00, Fire Detection and Alarm Systems.

2. Power and control wiring, excluding Cat 6A cable, shall be stranded conductors.

3. Provide terminal blocks at both sides of shipping splits to connect wiring between shipping sections.

4. Provide and tag wires and cables required for connecting the terminal blocks of the shipping sections.

5. Provide dedicated conduits to segregate fire detection and alarm circuits.

D. Circuit Breakers and Panelboards

1. Refer to Contract Specifications Section 26 24 24, Circuit Breakers and Panelboards, for requirements.

   a. Provide spare circuit breakers, three 20-amps and one 30-amps, in each panelboard.

   b. Spaces: Provide a minimum of eight circuit breaker spaces in the L01 panelboard and two circuit breaker spaces in the L02 panelboard for future installation of circuit breakers. The bus in each panelboard shall extend to cover the spaces for future circuit breakers.

E. Dry-Type and Isolation Transformers

1. Refer to Contract Specifications Section 34 21 28, Auxiliary Power Transformers (Dry Type), for requirements, with the following exceptions:

   a. Housings shall be NEMA 1 with a ventilated screen.

b. Unless otherwise indicated on the Contract Drawings, transformer shall be sized to provide at least 30 percent spare capacity over the initial maximum demand load.

F. Grounding

1. Ground test stations shall be provided, as indicated, along the bottom and inside wall of the AC and DC equipment houses and shall be interconnected by an insulated copper cable sized at no less than 250 kcmil.

2. Ground test station shall be shown in the Contract Drawings.

3. Provide ground test stations in the DC equipment house with non-metallic enclosures and insulate the interconnecting ground cables between test stations.

4. Grounding shall conform to the requirements specified in Contract Specifications Section 34 21 60, Grounding and Bonding for Traction Power Distribution.

5. Uniquely identify each ground test station with a wall mounted sign directly above the ground test station.

G. Wiring Devices

1. Provide one duplex, 20-ampere, 120-volt, three-wire receptacle with integral ground fault protection inside the house near each entry door. The receptacle shall be NEMA 5-20R configuration:

2. Provide an exterior GFCI, NEMA 5-20R duplex receptacle, with an enclosure that is weatherproof whether the attachment plug is inserted or not, at 18 inches above grade in the center of the “long” wall.

3. Wiring devices shall be in accordance with Contract Specifications Section 34 21 50, Common Materials and Methods for Traction Power and Contract Specifications Section 34 21 70, Traction Power Facilities Installation Requirements.

H. Conduit, Wireways, Boxes and Fittings

1. Refer to Contract Specifications Section 20 50 13, Raceway for Facility Services, for requirements.

2. Conduits within dc equipment houses except those used for fire alarm circuits shall be extra heavy-wall reinforced thermosetting resin conduit (RTRC) conduit. Fire alarm circuits shall use GRS conduit.

3. Conduits shall not be routed above dc switchgear arc chutes.

2.11 FIRE DETECTION AND ALARM SYSTEM

A. Provide Class A type fire detection and alarm system conforming to NFPA 72, complete with ionization detectors, dual ion zone module, control panel, end-of-line device, power supplies, conductors, conduits and all other items of material and equipment required for a complete installation.

B. Provide addressable fire alarm system panel capable of cross zone incident verification.

C. Provide smoke and fire detectors within the AC and DC equipment houses, suitably ceiling mounted and spaced to provide as early warning as possible of the existence of a fire or smoke within the AC and/or DC equipment houses. Do not mount smoke detectors within three feet of the ceiling area above dc circuit breaker cubicles.

D. Provide a strobe light and a smoke and fire detectors in the battery room within the DC equipment house.

E. Locate fire alarm control panel as indicated in the Contract Drawings.

F. Local audible indication is not required.

G. Detectors shall not be battery powered nor shall they contain a radiation source. A combination of photoelectric and heat (fixed rate) types shall be used to provide detection of both smoke and flaming conditions.

H. System shall provide two separate alarm contacts. One contact shall be wired to CO2 panel for remote (SCADA) and local annunciation of detector activation. The second contact shall be provided to de-energize the HVAC units.

I. Activation of cross zone detector devices shall initiate Device 186 and 286 station lockout relays.

J. Refer to Contract Specifications Section 28 31 00, Fire Detection and Alarm System, for additional requirements.

2.12 ACCESS CONTROL AND INTRUSION DETECTION SYSTEM

A. Provide access control and intrusion detection system, including field devices, weatherproof covers (as applicable), boxes, control panel, end-of-line device, power supplies, conductors, conduit and all other items of material and equipment required for a complete installation.

B. Provide intrusion detection switches at each entry and equipment access doorway. Activation of an intrusion detection switch shall annunciate at authorized location as indicated in Contract Specifications.

C. Locate access control panel and access card readers as indicated in the Contract Drawings.

D. Local audible indication is not required.

E. Refer to Contract Specifications Section 28 10 01, Access Control Systems, for requirements.

2.13 CCTV EQUIPMENT

A. Provide CCTV equipment and the associated conduits and wiring as indicated in the Contract Drawings. The equipment shall comply with the requirements of Contract Specifications Section 28 41 29, Closed Circuit Television Systems.

2.14 COMMUNICATION SYSTEMS

A. General

1. Locate equipment as indicated in the Contract Drawings.

B. Telephone System

1. Refer to Contract Specifications Section 27 30 01, Telephone Systems, for requirements.

C. Communication Cables and Related Equipment

1. Refer to Contract Specifications Section 27 13 01, Communication Cables and Related Equipment, for requirements.

D. Trunk Radio System

1. Refer to Contact Specifications Section 33 83 06, Radio Network/Bi-Directional Radio Amplifier System, for requirements.

2.15 MISCELLANEOUS EQUIPMENT

A. Material for Traction Power

1. Materials (e.g. relays, termination blocks, lights, resistors, fuses, fuse holders, links, conductors) – Refer to Contract Specifications Section 34 21 50, Common Materials for Traction Power, for requirements.

B. HVAC Control Panel and Thermostats

1. Refer to Contract Specifications Section 23 09 00, Instrumentation and Control for HVAC, for requirements.

2.16 FASTENERS FOR ITEMS MOUNTED ON EXTERIOR WALLS

A. Fastenings for items attached to the exterior walls or doors of the AC and DC equipment houses (e.g. signs, supports for conduits and meter sockets) shall use corrosion resistant blind threaded inserts and/or stainless steel hardware and appurtenances, approved by the equipment vendor for the use, to prevent corrosion or water leaks.

2.17 STATIC SIGNAGE AND IDENTIFIERS

A. Provide hazardous/warning static signage on the exterior side of each walk-in and equipment access doorway where maintenance personnel will be exposed to energized components and/or conductors. Refer to Cal/OSHA for additional requirements.

B. Provide the following warning signage in high contrast reflective two inch to three inch lettering permanently mounted with screws on the exterior rear side of breaker cubicles (front and rear)

1. “Caution Shock Hazard - Various components may have retained residual operating voltages within this Breaker Cubicle”

2. “Consider circuit energized unless electrical clearance is established.”

C. Provide equipment house and traction power substation designation signs on house exterior doors per following requirements:

1. Make nameplates of three-ply laminated phenolic plates with bevel edges, engraved through the black face to expose the white core. Lettering shall be condensed gothic applied using a rounded or square cutter. V-shaped grooves will not be acceptable.

2. Nameplates shall have lettering not less than four inches high. The District will specify individual traction power substation designations to be used on these signs.

2.18 STORAGE CABINET AND FURNITURES

A. Documentation and Tool Storage Cabinet

1. Provide a heavy-duty steel cabinet suitable for the expected small spare parts, tools, operating and maintenance manuals, design documentation, as indicated on the Contract Drawings.

B. Furniture

1. Provide a retractable wall mounted desk and two fold up chairs, as indicated on the Contract Drawings. Minimum desk dimensions shall be 36 inches wide x 24 inches deep.

2.19 FIRE EXTINGUISHERS

A. Provide wall mounted fire extinguisher within three feet of each entry door, in accordance with Contract Specifications Section 10 40 00, Safety Specialties.

B. Fire extinguishers shall be of the carbon dioxide type, 20-pound capacity, and shall be wall-mounted.

2.20 LIFTING HOIST

A. Provide a permanent lifting hoist in each DC equipment house to lift the arc shoots of the DC circuit breakers.

2.21 MISCELLANEOUS MATERIALS

A. Safety Equipment

1. Refer to Contract Specifications Section 34 21 01, General Requirements for the Traction Power System, for requirements.

B. Grounding Cables

1. General

   a. Grounding cables shall be three feet longer than needed to reach from the point of ground connection to the farthest equipment element to be grounded.

   b. Grounding cables shall be extra flexible insulated cable.

2. AC Equipment grounds - provide two ground cable assemblies consisting of:

   a. On the side of the grounding cable assembly to be applied to the AC equipment, provide three (3) cables each of sufficient length to reach all phase conductors. Provide ground clamp at the end of each cable.

   b. On the side applied to the grounding connection one cable with ground clamp.

   c. Provide Hubbell G3359, C5000337, or Cooper #133036-8AL-S6, #133042-8AL-S6 ground clamps or approved equal.

   d. Cable shall be extra flexible, insulated, minimum 4/0.

3. DC Rectifier grounds - provide two ground cable assemblies consisting of:

   a. On the side of the grounding cable assembly to be applied to the equipment, four (4) cables each of sufficient length to reach all phases of each incoming delta and wye phase, and the positive and negative dc buses. Provide heavy duty clamps at the end of each cable suitable for connection to grounding knobs provided at the connection points.

   b. On the side applied to the grounding connection one cable with a suitable ground clamp.

   c. Cable shall be extra flexible, insulated, rated at 60KA for 15 cycles.

4. DC Switchgear grounds

   a. Provide two ground cables each of sufficient length to reach between dc buses and grounding points.

   b. Size, rating, and characteristics shall be as 2.20B.3 rectifier grounds.

C. Tools

1. Provide one set of tools in each AC and DC equipment house to operate and maintain the equipment.

2.22 SPARE PARTS

A. Furnish spare parts to the District in accordance with the approved spare parts list and/or as specified herein, whichever is the more restrictive for each AC and DC equipment house at each traction power facility:

1. Paint

   a. Provide two gallons for each equipment house supplied AC and DC equipment houses and associated equipment enclosures.

2. Heating, Venting and Air Conditioning Control Panels and Thermostats

   a. At least one thermostat per traction power facility.

   b. Consumables (e.g. fuses, lamps, and indication lights) - At least ten percent spares of general consumables shall be provided at each traction power facility.

3. Electrical

   a. Consumables (e.g. fuses, light fixtures, LED lamps, and indication lights) - At least ten percent spares of general consumables shall be provided at each traction power facility. Provide minimum two fuses of each type and size.

   b. Conductors and Fiber Optic Strands:

      1) At least 20 percent spare conductors shall be provided for all single and multi-conductor factory installed control and indication cables.

      2) At least 20 percent spare fiber strands shall be provided for all factory installed fiber optic cables.

4. Fire Detection and Alarm System

   a. Field devices (e.g. strobe light, smoke and fire detectors) - At least ten percent spares of field devices shall be provided at each traction power facility.

5. Refer to Contract Specifications Section 01 78 44, Spare Parts and Maintenance Materials, for additional requirements.

2.23 FACTORY ACCEPTANCE TESTING

A. Refer to Contract Specifications Section 01 45 24, Testing Program Requirements and Contract Specifications Section 34 21 75, Traction Power Facility System Level Factory Testing, for additional requirements.

B. Design Tests:

1. One empty house of each kind (AC and DC equipment house), complete with throat connection assemblies in the case of the DC equipment house, shall be tested in accordance with the weatherproofing test for outdoor metal-enclosed switchgear of IEEE C37.20.1 and IEEE C37.20.2.

C. Production Tests:

1. General: Tests specified herein shall be performed on each fully assembled prefabricated AC and DC equipment house. Tests shall be performed with all equipment installed and wired inside the AC and DC equipment house. All equipment components installed within houses shall have successfully passed the specified design and production tests. Refer to Contract Specifications Section 34 21 75, Traction Power Facility System Level Factory Testing.

PART 3 – EXECUTION

3.01 FOUNDATION COORDINATION

A. Examine foundations, leveling channels, stairways and exposed grounding embed conditions for compliance with the approved construction design and equipment house manufacturer's requirements prior to placement of the AC and DC equipment houses.

B. Note items that may infringe on the necessary clearances and other non-compliances. Promptly bring noted issues to the attention of the Engineer for direction and approval before proceeding.

C. Corrective actions, as required, shall be undertaken by the Contractor at no cost to the District.

3.02 FIELD INSTALLATION

A. Place cranes and rigging in accordance with the approved rigging plan.

B. Install the AC and/or DC equipment house on the foundation secure, level (with stainless steel shims (if required), plumb and in true alignment with related adjoining work.

C. Control erection tolerance requirements so as not to impair the strength, safety, serviceability or appearance.

D. Exercise special care during installation to avoid overloading any part of the structure. Repair or replace any item damaged due to overloading, at no cost to the District.

E. Re-assemble shipping splits in accordance with the approved equipment vendor designs and requirements including joint and weatherproofing sections of each AC and DC equipment house.

F. Connect raceways and circuits between shipping split sections and control circuits between equipment inside the AC or DC equipment house.

G. Secure the AC and DC equipment houses to the leveling channel in accordance with equipment vendor's recommendations and the approved seismic design.

H. Install grounding connections to the underground ground grid pigtails per the approved construction and/or equipment vendor designs, and in accordance with Contract Specifications Section 34 21 60, Grounding and Bonding for Traction Power Facilities.

I. Apply waterproof, non-hardening sealing compound between the foundation and house base perimeter.

J. Leave the AC and/or DC equipment house lifting lugs, complete with boxed hardware, in each house for future use by the District.

K. Install conduits, wireways, cable trays (to route field installed cables/conductors) and mounting hardware within the AC and DC equipment houses in accordance with Contract Specifications Section 20 50 13, Raceways for Facility Services.

L. Field cables, conductors and jumpers shall be installed in conduits, wireways and/or cable trays.

M. Provide panel schedules inclusive of traction and non-traction power electrical loads.

N. Protect floor and wall surfaces during field installation and field testing activities. Touch-up electrical insulation and finished surfaces prior to final acceptance of the AC and DC equipment houses.

O. Refer to Contract Specifications Section 34 21 70, Traction Power Facilities Installation Requirements, for additional requirements.

P. Interconnect all control and indication functions specified herein to the CO2 cabinet for local and remote operation/monitoring in accordance with Contract Specifications Section 34 21 33, Control, Monitoring and Display Panel**.**

3.03 THIRD PARTY WATER AND ELECTRIC UTILITY SERVICE CONNECTIONS

A. Install metering enclosure, conduits (on line side of meter), mounting hardware and pads in accordance with the approved design and the third party electric utility service provider requirements.

B. Install conduits, mounting hardware and cables on the load side of the metering enclosure in accordance with Contract Specifications Section 20 50 13, Raceways and Facility Services, and Contract Specifications Section 26 05 24, Low Voltage Wires and Cables.

C. Seal wall penetrations of the AC and DC equipment houses in accordance with the manufacturer's requirements.

D. Coordinate water and sewer connections with local municipality, city, and county.

3.04 FREEZE AND CONDENSATION PROTECTION

A. Protect AC and DC equipment house interiors and equipment from freezing and/or condensation conditions by sealing openings and maintaining inside temperature above 40 degrees Fahrenheit at all times, and particularly while in transit and storage, and during the time lag between setting down on foundation and energization. For the latter, and for any time the AC and DC equipment house is stored outdoors, use the building and equipment space heaters, with power supplied from a temporary LV AC power source, to maintain the required temperature limit.

3.05 FIELD TOUCH-UP

A. Remove paint splatters and other spots.

B. Clean and repaint damaged interior and exterior surface coatings of the AC and/or DC equipment house and frame with the same coating system used in the factory, using touch up paint provided by the AC and/or DC equipment house manufacturer

C. Painting shall follow closely the recommendations of the AC and/or DC equipment house and paint manufacturers.

D. Provide the appearance of a new installation prior to final acceptance.

3.06 INSTALLATION VERIFICATION AND FIELD FUNCTIONAL AND SYSTEM INTEGRATION TESTING

A. Refer to Contract Specifications Section 34 21 80, Traction Power System Field Acceptance Testing, for additional requirements.

B. As part of installation verification testing activities a circuit breaker shall be rolled out of each equipment house (at each traction power facility) onto the designated stairway landing and back into the house while allowing safe opening and closing of the door without:

1. Removing door sills.
2. “Bridging” the circuit breaker on the door sill.
3. Lifting the circuit breaker in such a way as to cause mechanical damage.

Mitigate any condition inhibiting easy movement of circuit breakers into and out of equipment houses to the satisfaction of the Engineer.

3.07 CLEANING

A. Refer to Contract Specifications Section 01 74 14, Cleaning, for additional requirements.

B. On completion of testing, per manufacturer's written instructions, clean all AC and DC equipment houses and associated equipment. Vacuum dirt and debris. Compressed air to assist in cleaning shall not be used.

3.08 DEMONSTRATION AND TRAINING

A. Refer to Contract Specifications Section 01 79 00, Demonstration and Training, for additional requirements.

B. Contractor shall provide a factory-authorized service representative from the manufacturer for equipment demonstration and training of District's personnel to adjust, operate, and maintain the AC and DC equipment houses and associated equipment, as required by Contract Specifications Sections 01 45 24 Testing Program Requirements and 34 21 01 Traction Power General Requirements, Part 3.

3.09 CLOSEOUT PROCEDURES

A. Refer to Contract Specifications Section 01 77 00, Closeout Procedures, and Contract Specifications Section 01 78 39, Project Record Documents, for requirements.

END OF SECTION 34 21 05

SECTION 34 21 11

MULTI-FUNCTION PROTECTION RELAY EQUIPMENT FOR DC FEEDER CIRCUIT BREAKERS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Multi-function protection relay (MPR) equipment for DC feeder circuit breakers

B. MPR Main Processor

C. DC feeder circuit breaker automatic reclose function

D. Short circuit protection functions

E. Reverse current protection for DC main circuit breakers

F. Contact rail potential indication function

G. Other internal logic functions

H. Ethernet interface functions

I. MPR discrete input/output (I/O)

J. Data recording and retrieval functions

K. Security functions

L. Self-monitoring functions

M. MPR operator interface panel

N. MPR high-voltage measurement DC buffer amplifier

O. MPR power supply

P. Test and maintenance accessories

Q. Factory testing

1.02 MEASUREMENT AND PAYMENT

A. Separate measurement and payment will not be made for work required under this Section. All costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work of this Contract.

1.03 REFERENCES

A. Electronics Industries Association (EIA):

1. EIA 232-F Interface Between Data Terminal Equipment and Data Circuit –Terminating Equipment Employing Serial Binary Data Interchange

2. EIA 455-11-177A Standards for Test Measurements and Inspection of Fiber Optic Cables, Connectors, and/or Other Fiber Optic Devices

B. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE 37.90 Standard for Relays and Relay Systems Associated with Electric Power Apparatus

2. IEEE 37.90.1 IEEE Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus

3. IEEE 37.90.3 Standard Electrostatic Discharge Tests for Protective Relays

4. IEEE 802.3 Carrier Sense Multiple Access with Collision Detection

C. National Electrical Manufacturers Association (NEMA):

1. NEMA WC70/ ICEA S-95-658 Standard for Non-Shielded Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy

D. National Fire Protection Association (NFPA):

1. NFPA 70 National Electric Code

2. NFPA 262 Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air Handling Spaces

E. Underwriters Laboratories (UL):

1. UL 1581 Standard for Safety Electrical Wires, Cables, and Flexible Chords

1.04 SUBMITTALS

A. Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Submit the following to demonstrate compliance with applicable standards:

1. Where equipment or materials are specified to conform to the standards of organizations such as ANSI, IEEE, NEMA, and UL, submit evidence of such conformance. The label of the specified agency will be acceptable evidence.

2. As an alternative to the label or listing, submit a written certificate from an approved nationally recognized testing organization, adequately equipped and competent to perform such activities, stating that the items have been tested and that the units conform to the specified standards.

C. Submit the following as a minimum:

1. MPR product data, providing name of manufacturer, model/brand/catalog number, and one copy each of the applicable standards for each major component. Submittal shall be made in one package with a listing of the components arranged and identified in numerical sequence by article numbers within this Specification section.

2. Design drawings include:

   a. MPR block diagram showing specified functional interfaces with external equipment including the DC switchgear, control and annunciator panel (C02), and communications equipment.

   b. MPR elementary control diagrams depicting logical functions or equipment including interfaces with the C02 panel and communications equipment.

   c. Automatic reclosing system software logic diagram.

3. Required fusing, wiring, and other control circuit requirements.

4. Recommended MPR automatic reclosing and overcurrent protection settings.

5. Communications protocols demonstrating compatibility with protocols specified herein and the BART Communications Protocol (BCP).

6. MPR installation requirements for design coordination with the DC switchgear equipment layout.

7. Factory design and production test procedures and data sheets.

8. Recommended field test procedures and data sheets.

D. Submittals shall be made in both electronic format using the latest version of AutoCAD, and hard copy format.

PART 2 – PRODUCTS

2.01 GENERAL REQUIREMENTS

A. The MPR equipment shall provide data monitoring of the 1000 V DC bus; DC feeder circuit breaker controls, indications, and protection; I/O control functions; data logging; event recording; operator's interface; local & remote communication capabilities; and, other functions as indicated for DC feeder circuit breakers in traction power substations (TPSS's) and gap breaker stations (GBS's).

B. The MPR shall function properly in the BART system having the following characteristics:

1. Peak fault current – 100,000 amperes, maximum (DC feeder fault current in a 10 MW traction power substation).

2. Peak system operating current: For mainline DC feeder circuit breakers, load current peaks of up to 12,000 amperes for up to 20 second duration.

3. Rail Impedances:

   a. Low Resistance Contact Rail: 0.00225 ohms/1000 feet

   b. Standard Contact Rail: 0.00387 ohm/1000 feet

   c. Running Rail (one track; two rails): 0.00485 ohms/1000 feet

C. The MPR shall be designed so that parts requiring adjustments and maintenance are easily accessible. The MPR shall be designed for 40 years' service life.

D. MPR equipment shall be microprocessor based and shall include operational modules located in the following DC switchgear compartments:

1. A main processor that includes an operator interface panel shall be in the breaker control cubicle in a low voltage area.

2. A high-voltage signal measurement DC buffer amplifier, located in the associated 1000 V DC feeder bus compartment.

E. MPR equipment shall include hardware, software, and ancillary circuits inter-connecting the various MPR equipment modules, which shall implement the functional requirements specified herein.

F. Environmental Immunity Requirements: The MPR shall be designed to operate properly and without malfunctions under the following environmental and service conditions:

1. Ambient Temperature: From -20 degrees to +50 degrees Celsius in accordance with IEEE 37.90-5.1.1.

2. Humidity: Up to 55 percent humidity outside the switchgear enclosure at temperatures up to 40 degrees Celsius, with excursions up to 95 percent humidity for a maximum of 96 hours, without internal condensation.

3. Dust: Extremely dusty environment; and enclosure shall at a minimum meet the requirements of a NEMA 12 type installation.

4. Electromagnetic Interference (EMI): The MPR shall function continuously and without error when subjected to electromagnetic interference and static discharges present in the vicinity of 1000 V DC and 34.5 kV AC power circuits.

5. Noise Rejection – Shall meet requirements of IEEE C37.90.1, Surge Withstand Capability (SWC) Tests.

G. The MPR shall be capable of processing Ethernet and discrete input/outputs concurrently.

2.02 MPR MAIN PROCESSOR

A. The main processor board shall include following hardware as a minimum for implementing the functions specified herein:

1. Processor: 32-bit RISC processor or equal.

2. Memory: Three memory modules shall be provided as listed below. Both flash EPROM and NVRM shall be non-volatile and shall be used to save and retain the equipment software, system parameters and settings, alarm log and data traces. The memories shall be designed and configured to retain the software, settings, parameters, alarm logs, and recorded traces and other pertinent information without any power requirements. Memory capacity shall, as a minimum, be as follows:

   a. 16 MB of RAM working memory

   b. 16 MB of flash EPROM memory

   c. 8 KB of non-volatile memory (NVRAM) to store system parameters and alarm log.

3. Watchdog circuit for processor supervision.

4. System clock with power backup for at least 30 Days. The system clock shall be capable of being automatically updated by the BARTNet system clock using Network Time Protocol or Simplified Network Time Protocol.

5. Communication Ports: The following communication ports shall be provided:

   a. A dedicated fiber optic communication controller shall provide a high-speed serial interface to the DC buffer amplifier. The controller shall also monitor the integrity of the DC buffer amplifier and the link.

   b. A minimum 10/100 Mbps primary Ethernet port to communicate with the PLC in the C02 panel. The port shall be equipped with 10Base-FX send/receive ports with ST connectors for multimode fiber.

   c. A minimum 10/100 Mbps secondary Ethernet/IP communications port to communicate with remote terminals over the BARTNet Ethernet system. The port shall be equipped with 10Base-FX send/receive ports with ST connectors for multimode fiber.

2.03 DC FEEDER CIRCUIT BREAKER AUTOMATIC RECLOSE FUNCTION

A. MPR shall provide load measuring and automatic reclosing circuits for DC feeder circuit breakers. Reclosing logic shall permit bi-directional automatic re-closure; and shall permit load measuring when one side of the feeder circuit breaker circuit is energized and with the other side either energized or de-energized. The MPR shall prohibit reclosing if the DC buses on both sides of the DC feeder breaker are de-energized.

B. Automatic reclose function shall have the ability to lockout. Lockout blocks operation of facility circuit breakers until lockout is manually cleared.

C. Provide sufficient noise immunity to achieve the required voltage measurement sensitivity during peak period system operation.

D. Automatic Reclosing System Parameters – The MPR shall at a minimum provide the following adjustable automatic reclosing system parameters. These parameters shall be adjustable as described below:

1. Bus Voltage High Threshold: 600 to 1000VDC

2. Bus Voltage Low Threshold: 0 to 600VDC

3. Minimum Load Resistance to Allow Reclosing: 0.1 to 0.4 Ω, adjustable in steps of not greater than 0.1 Ω.

4. Load Measurement Pulse Duration: 0.1 to 9.9 seconds, adjustable in steps greater than 0.1 seconds.

5. Delay between successive load measuring pulses: 1 to 99 seconds, adjustable in steps of not greater than 1 second.

6. A Load Measurement Delay shall be used to avoid possible confusion between two or more MPRs attempting to reclose DC feeder breakers connected to the same contact rail section, so that a test voltage placed on the contact rail section during one MPR's load measuring cycle will not cause a misleading voltage reading during the voltage checking part of a second MPR's reclosing cycle. Load Measurement Delay shall be parameterizable by the following 3 variables:

   a. Lead Delay.

   b. Neutral Delay.

   c. Follow Delay.

7. Lead, Neutral, Follow Time Delay: 0 to 10 seconds, adjustable in steps not greater than 1 second.

8. Delay before starting first load measurement cycle: 2 to 9 seconds.

9. Successfully Closed Time (The time breaker shall remain closed to consider a successfully closed breaker): 0.5 to 3 seconds, adjustable in steps not greater than 0.5 seconds.

10. Load Measurement Attempt Counter (Number of times load measuring is attempted during one load measuring cycle): 1 to 4 attempts.

11. Close Attempts (Number of times the circuit breaker is allowed to close and trip again during the Successfully Closed Time interval before system initiates a 'soft' lockout. Sending the DC feeder breaker a trip command shall clear a soft lockout.): 1 to 4 attempts.

12. Soft Lockout Timer (Total time for the closing process before entering the soft lockout state): 1 to 99 minutes.

13. Hard Lockout Timer (Time during which a set number of soft lockout resets initiates a 'hard' lockout. Only pushing the RESET or similar button on the Operator Interface can clear a hard lockout. Pushing the RESET button converts a hard lockout to a soft lockout: 1 to 99 minutes, adjustable in steps not greater than one minute.

14. Soft Lockout Counter (Number of soft lockout resets given during the Hard Lockout Timer that is necessary to force the MPR into the Hard Lockout state): 1 to 5.

E. Automatic Reclosing System Functional Logic – MPR Automatic Reclosing System logic shall operate in accordance with the Automatic Reclosing Routine Logic Diagram shown in Figure 1 in the Attachment to these Specifications, and the following text description:

1. Upon receipt of a Trip command, increment the Soft Lockout Counter. If the Hard Lockout Timer = 0, then start the Hard Lockout Timer. If Soft Lockout Counter = 1 to 5, and Hard Lockout Timer $\geq$ 99 minutes then go to the hard lockout state and indicate hard lockout.

2. Upon receipt of a Close command, if the MPR has previously been reset by a Trip command to enable closing and if the MPR is neither in hard nor soft lockout, then initiate the automatic reclosing cycle.

3. On initiation of the auto-reclose cycle, measure voltages on both buses of the DC feeder breaker in accordance with the following logic:

   a. If voltages on both DC feeder breaker buses are > Bus Voltage High Threshold, then the DC circuit breaker shall be closed. If circuit breaker remains closed for longer than the Successfully Closed Time, then the appropriate counters and timers shall be reset.

   b. If voltage on one side of the DC feeder breaker > Bus Voltage High Threshold and voltage on the other bus is < Bus Voltage Low Threshold, then load measuring shall commence, and load Measuring/reclosing shall be indicated.

c. If either Bus Voltage Low Threshold < bus voltage < Bus Voltage High Threshold on line or load side of DC feeder breaker bus, or Bus Voltage Low Threshold < bus voltage for both buses, then monitoring of bus voltages during Soft Lockout Timer shall continue. Such voltage levels shall be unacceptable, and DC feeder breaker closing shall be prohibited when either of these conditions exists. If during the Soft Lockout Timer the voltage states change to those of either case (3a) or (3b), then action as indicated by the appropriate case shall be taken. If unacceptable voltage levels remain after Soft Lockout Timer has expired, then soft lockout shall be indicated, operation shall proceed to soft lockout state, and the appropriate counters and timers shall reset.

4. Prior to commencement of load measuring, the Load Measuring Attempt Counter shall be set equal to 1. Then the load measuring circuit contactor (Device 173) shall be closed, and the voltage across the load-measuring circuit resistor (across the open DC feeder breaker) shall be measured. If the measured load resistance between the contact rail and negative return rail is ≥ Minimum Load Resistance to Allow Reclosing, then the DC feeder breaker shall be allowed to close. If the circuit breaker remains closed for longer than the Successfully Closed Time, then the appropriate counters and timers shall be reset. If the measured load resistance is < Minimum Load Resistance to Allow Reclosing, then the Load Measuring Attempt Counter shall be incremented and another reclosing cycle shall be initiated.

5. If the Load Measuring Attempt Counter reaches maximum attempts, then operation shall proceed to the soft lockout state, soft lockout shall be indicated, and the appropriate counters and timers shall be reset.

6. If the number of successful reclosures and subsequent trips during the Successfully Closed Time > maximum close attempts, then soft lockout shall be indicated and operation shall proceed to the soft lockout state. The appropriate counters and timers shall be reset.

7. The Soft Lockout Counter shall keep a running count of Trip commands during the active Hard Lockout Timer. If a period of more than the Hard Lockout Timer passes with not more than one Trip command received, then the Hard Lockout Timer counting period shall automatically reset to zero.

F. Automatic-Reclosing Logic Negative Rail Potential Rise Compensation: When evaluating contact rail voltage, the MPR shall measure the voltage between the DC positive contact rail and the DC negative return rail. This measured voltage shall be greater than the Bus Voltage High Threshold in order to allow reclosing of the DC feeder breaker.

2.04 SHORT CIRCUIT PROTECTION FUNCTIONS

A. MPR shall implement short circuit protection for DC circuit breakers. Provide, as a minimum, the following protective functions: Breaker tripping for Instantaneous, Inverse-Time, Extremely Inverse, Low Level Fault, Reverse, and Rate of Rise Overcurrent functions. They shall be initiated when the Current > Trip Threshold, and Time > Trip Delay.

B. Instantaneous Overcurrent Trip (feeder breaker).

1. Function Includes Trip Threshold and Trip Delay

2. Function includes bi-directional sensing of current

C. Inverse-time Timed Overcurrent Trip (feeder breaker): Provide time overcurrent trip function with inverse time characteristic that can be graphed with the Set Current, as the y-axis, and the Time Delay, as the x-axis. Tripping shall be initiated when the Load Current exceeds the Set Current during the period of time t such that (t/Time Delay) and (Load Current/Set Current) correspond to a point on the curve.

1. Function includes bi-directional sensing of current in both directions

D. Extremely Inverse Overcurrent Trip (feeder breaker).

1. Function includes bi-directional sensing of current

E. Low Level Fault Trip (feeder breaker).

1. Function includes Trip Threshold and Trip Delay

2. Function includes bi-directional sensing of current

F. Reverse Overcurrent Trip (main breaker).

1. Function includes Trip Threshold and Trip Delay

G. Rate of Rise (di/dt) Trip (feeder breaker).

1. Function includes current trip limit, current rise limit, and current duration delay time

2. Rate of rise trip shall be initiated if the following conditions are met:

   a. Current exceeds the trip limit

   b. di/dt stays above the trip limit during the delay time

   c. During the delay time current exceeds the current rise limit

2.05 CONTACT RAIL POTENTIAL INDICATION FUNCTION

A. Provide Contact Rail Potential Indication function with the following user-adjustable parameters:

1. Pick-up Voltage Threshold: 0 to 1000V

2. Hysteresis: 0 to 300V. When the contact rail indication pickup voltage has indicated an undervoltage condition, then Pick-up Voltage Threshold Hysteresis shall be the value at which the relay 'drops out' and the undervoltage indication becomes inactive. When the measured voltage falls below the Pick-up Voltage Threshold – Hysteresis value, the contact rail undervoltage indication, a green LED, shall become active.

3. Contact Rail Potential Undervoltage Pickup Delay: 0 to 3 sec.

B. The Contact Rail Potential Indication function shall be fail-safe such that in the event of MPR equipment function failure, contact rail energized, a red LED, shall be indicated.

2.06 OTHER INTERNAL LOGIC FUNCTIONS

A. Close Command with Circuit Breaker in Test Position: With a circuit breaker in TEST position, its associated MPR shall issue a Close command to the circuit breaker upon receipt of a Close command input from the corresponding breaker test control switch mounted on the breaker cubicle door. Under this condition the circuit breaker shall close without load measuring.

B. Load Measure Command: The MPR shall issue a Load Measure command using a discrete dry contact relay output, when directed to do so by the automatic reclosing logic, provided the following conditions are satisfied:

1. Circuit breaker is open.

2. Door switch interlock indicates that circuit breaker cubicle door is closed.

3. Circuit breaker is in the CONNECTED position.

C. Directional Current, Forward and Reverse

1. The MPR shall receive output current from the shunt in the forward direction (main bus to feeder bus) and the reverse direction (feeder bus to main bus).

2. The MPR directional current functions shall detect current levels of at least 25 percent of the rated shunt current.

D. Transfer Trip Initiate Commands, Forward and Reverse

1. The MPR shall issue a Transfer Trip Initiate command when the Transfer Trip Initiate logic is true, and the following conditions are satisfied:

   a. Circuit breaker direct acting series trip input is activated or the MPR detects an overcurrent condition.

   b. MPR current direction logic detects either forward or reverse shunt current flow.

2. Transfer Trip Initiate command shall be issued through discrete dry contact relay outputs, one for Transfer Trip Initiate Forward, and another for Transfer Trip Initiate Reverse as described herein. MPR shall be provided with a means to allow the District to choose between forward or reverse current flow.

2.07 ETHERNET INTERFACE FUNCTIONS

A. The MPR shall accept and communicate the following I/O functions through the primary Ethernet port connecting to the control and annunciator panel (C02) PLC, specified in Section 34 21 33, Control, Monitoring and Display Panel:

1. Inputs

   a. Breaker TRIP command (non-reclosing)

   b. Breaker CLOSE command

2. Outputs

   a. Breaker OPEN indication

   b. Breaker CLOSE indication

   c. Trip-reclose indication

   d. Contact rail undervoltage (latching, defined so that system defaults to ‘RAIL ENERGIZED’ state upon MPR indication failure)

   e. MPR soft lockout indication

   f. MPR hard lockout indication

   g. Transfer trip forward (current flow from DC main bus to feeder bus)

   h. Transfer trip reverse (current flow from DC feeder bus to main bus)

   i. MPR trouble/loss of control power output (latching, normally closed (NC))

   j. Analog data output: Instantaneous DC main and feeder bus voltages, and DC feeder bus current. A sampling rate of at least 1 second shall be used for these analog data when communicating values to the BART network.

B. A secondary Ethernet port shall allow access to MPR system diagnostic data only. This port shall provide no ability to control the MPR or alter any MPR parameter setting.

1. The following diagnostic functions shall be available through the secondary Ethernet port:

   a. View analog data: Instantaneous DC main and feeder bus voltages, and DC feeder shunt current.

   b. View and download alarm log

   c. View and download oscilloscope data traces

d. View MPR parameter settings

2. Secondary Ethernet port shall be remotely accessible over the BARTNet system using TCP/IP protocol.

3. The secondary Ethernet port shall be locally configurable to allow uploading of software upgrades and modifying relay parameters from a remote computer.

2.08 MPR DISCRETE I/O

A. General – The MPR shall be equipped with discrete I/Os and a circuit breaker tripping output as described below. The I/O board shall be powered from the MPR main module. I/Os shall be optically isolated and filtered and shall have LEDs or indications for status annunciation.

B. Discrete Inputs – Each input shall be powered from the MPR controller and shall accept input voltage levels between 32 and 125 V DC. A step-up or step-down transformer may be used to achieve the required voltage. Programmable discrete inputs shall be as follows:

1. Breaker CLOSE command

2. Breaker TRIP (non-reclosing trip) command

3. Breaker TRIP-RECLOSE command: The Trip-Reclose command input shall cause circuit breaker to trip immediately. Following tripping of circuit breaker due to Trip-Reclose signal, the MPR shall take no action until cessation of the Trip-Reclose input signal. Upon cessation of the Trip-Reclose command, the circuit breaker shall attempt reclosing.

4. Breaker auxiliary indication (Open/Closed)

5. Breaker direct acting series trip indication

6. Breaker position indication (Test/Connected)

7. Breaker cubicle door indication (Open/Closed)

8. System control power ON

9. Two general-purpose programmable inputs

C. Discrete Outputs – Relay output contacts shall be current rated for 5A and rated with maximum contact voltage of 150 VDC. The outputs shall be programmable to provide maintained or non-maintained operation, with the non-maintained signal duration programmable from 0.5 to 3.0 seconds. Programmable outputs shall be as follows:

1. Close breaker command

2. Load measure

3. Circuit breaker Open indication

4. Circuit breaker Closed indication

5. Current flow forward (current flow from DC main bus to feeder bus)

6. Current flow reverse (current flow from DC feeder bus to main bus)

7. Summary trouble alarm, includes loss of control power

8. Two general-purpose programmable outputs

D. The MPR shall have an optically isolated triggering circuit, rated for 40A for 0.5 sec, rated for 1A minimum continuous current and 300 V DC maximum voltage. This output will be used for the breaker trip command. The triggering pulse shall be programmable between 0.5 and 3 seconds.

E. Each MPR I/O, including the tripping output, shall have an associated LED or indication on the I/O board that indicates:

1. Input received

2. Output relay picked up

3. Tripping output active

2.09 DATA RECORDING AND RETRIEVAL FUNCTIONS

A. Alarm Memory – The MPR shall, at a minimum, retain records of the last 200 trips and alarms with date and time stamps. Alarms shall include trip events, failures to reclose, and system malfunctions. The following alarm indications shall, as a minimum, be provided:

1. Rate of Rise

2. Instantaneous Overcurrent

3. Reverse Overcurrent

4. Timed Overcurrent

5. Low Level Fault

6. Breaker Trip-Reclose

7. Uncommanded Breaker Trip

8. Breaker Closure Timeout

9. Soft Lockout Initiated

10. Hard Lockout Initiated
11. Closure Fail (volt level)
12. Closure Fail (de-energized)
13. Closure Fail (success timeout)
14. Contact Rail Undervoltage
15. Incomplete Sequence
16. DC buffer amplifier initialization problem
17. DC buffer amplifier data problem
18. Warning Current

B. Voltage and Current Records

1. Oscilloscope: Built in softscope-type oscilloscope shall allow snapshots of voltage and current, before and after a triggering event. Oscilloscope shall have the capability of recording up to ten simultaneously active triggering events, at a minimum. The alarm events shall be selectable such that they include positive overcurrent, negative overcurrent, positive overvoltage, negative overvoltage, and other abnormal system conditions.

2. MPR shall retain oscillogram records of voltage and current traces for at least the last ten preset alarm events. These alarm events shall be retained in the non-volatile memory and shall be retrievable even after complete power failure to the MPR.

3. Each oscillogram data record shall consist of two sets of data:

   a. One set shall store samples for the period of time at a minimum of 220 milliseconds before a tripping action and at a minimum 40 milliseconds after the tripping action, with at a minimum 65 microseconds sampling interval.

   b. The second set shall store samples for the period of time at a minimum of 230 seconds before and at a minimum 30 seconds after a tripping action, with at a minimum 65 microseconds sampling interval.

   c. Data trace triggering events shall be selected from among the alarm events specified above.

2.10 SECURITY FUNCTIONS

A. MPR shall provide the following password-protected security levels, as a minimum:

1. Observer: Lowest security level, no password required to access Observer level.

   a. Allows viewing of relay parameter settings and stored data.

b. Does not allow access to system security passwords.

2. Supervisor: In addition to Observer level permissions, allows:

a. Modifying time and date

b. Downloading alarm log and stored data traces

3. Expert: In addition to Supervisor permissions, allows:

a. Modifying parameters

b. Modifying Supervisor and Expert security passwords

B. A physical lock and key type security system is not acceptable.

2.11 SELF-MONITORING FUNCTION

A. MPR shall initiate a self-test on power-up and shall continuously monitor internal operations using a watchdog circuit. If the controller fails to toggle the watchdog circuit for more than one second, the watchdog circuit shall initiate a trouble alarm. The MPR shall indicate system trouble locally by an LED located on the Operator Interface Unit. In addition, the MPR shall be provided with an output relay contact and an alarm signal available at the MPR's primary Ethernet port. Alarms shall be stored in the alarm log.

B. As a minimum, the MPR shall perform the following series of self-test functions when control power is connected to the MPR:

1. Test of non-volatile and volatile memories

2. CPU test

3. Power supply voltages normal

4. System monitoring active

5. Output relays functional

6. Primary and secondary Ethernet connections active

C. MPR shall allow access for internal system diagnostics through the operator keypad, and through the secondary Ethernet/IP network connection.

D. Main processor shall monitor the DC buffer amplifier and shall initiate MPR trouble alarm upon any malfunction.

2.12 MPR OPERATOR INTERFACE PANEL

A. Display – Provide TFT/LCD active matrix color display or LED backlighting display with the following characteristics:

1. Active area: 6.4 inches by 4.8 inches, minimum.

2. Diagonal size: 8.0 inches, minimum.

3. Resolution: 640 by 480 pixels, minimum.

4. Response time: 80 ms, minimum.

B. Operator's interface: Provide either keyboard or touch screen that allows user to view the alarm log and system diagnostics, and to change user-adjustable parameters.

1. Operator keypad: A numeric and arrow membrane keypad controlling the display panel.

2. Touch screen: The display shall act as a touch screen.

C. System shall allow user to access system parameters, status, control, and indication through hierarchical graphical menus viewed on the Operator Interface Panel viewing screen and controlled through the operator interface.

D. The top level default screen shall display:

1. Present instantaneous DC feeder breaker line voltage, load voltage, and shunt current.

2. System status indications, including "System Healthy", "Lockout", "Hard Lockout", and "Overcurrent Trip".

E. User shall be able to access system sub-menus from the top level screen, including:

1. General system functions including shunt and system configuration parameters.

2. Protection function parameters, including:

   a. Instantaneous, Timed, Low Level, and Reverse Overcurrent

   b. Rate-of-Rise

   c. Contact Rail Potential

3. Automatic Reclosing function parameters, including voltage, load measuring, timing, lockout, and hard lockout.

4. Command functions including alarm log, time and date, security level, and password definition.

5. Gain adjustments that allow user to adjust 1000 V DC system measured voltage and current gain to within ± 1 percent of actual, independently measured values.

6. Help functions, including context-sensitive how-to operating instructions

F. Parameter display screens shall highlight parameter settings that are adjustable at user's present security level.

2.13 MPR VOLTAGE AND CURRENT MEASUREMENT DC BUFFER AMPLIFIER

A. MPR shall obtain voltage and current indications using DC buffer amplifier mounted in the switchgear 1000 V DC circuit breaker compartment as near as possible to its associated shunt. The DC buffer amplifier and its ancillary hardware and cables shall be sufficiently rugged to withstand dust, dirt, and thermal, mechanical and electrical stresses associated with 1000 V high current DC circuits.

B. DC buffer amplifier shall have following minimum characteristics:

1. Isolation:

   a. Continuous: 4 kV

   b. Peak: 6.8 kV test

2. Accuracy: ± 2 percent full scale

3. Current range: 0 – 40 KA

4. Mounting: Of adequate strength to withstand thermal and mechanical stresses associated with the maximum short-circuit currents equal to the interrupting rating of the circuit breakers.

5. DC buffer amplifier shall derive voltage and current measurements from electrical connections with line and load sides of DC circuit breaker, and with a DC shunt.

C. Connection between DC buffer amplifier and main processor

1. The fiber optic connection between the DC buffer amplifier and main processor shall transmit a current and voltage sampling pulse signal, and a link integrity pulse signal, between microcontroller and DC buffer amplifier once every 0.5 seconds, at a minimum.

2. Serial data connection shall be flexible duplex fiber optic cable, of small bend radius, certified to meet EIA-455-11-177A.

D. The DC buffer amplifier's ancillary equipment shall include any bleeder resistors between DC positive and negative buses, and shall provide adequate filtering of any random switchgear operating transient voltages to assure correct MPR indication and control.

2.14 MPR POWER SUPPLY

A. MPR shall be designed for operation with either 125 V DC or 120 V AC power supply from the station power sources. Normal power shall be from 125 V DC, and in case of normal power failure, the MPR shall automatically switch over to 120 V AC back up supply without losing any of its functionality. The MPR shall operate over a range of +10 to -15 percent of rated voltage.

2.15 TEST AND MAINTENANCE ACCESSORIES

A. Furnish a complete set of special tools and test equipment, for each 15 MPRs provided, and at least 1 complete set. The set comprises hardware and software necessary for field testing, diagnostics, maintenance and repair of the MPR, including the DC buffer amplifier. At a minimum, each set of test apparatus shall comprise the following:

1. Laptop computer shall be the current generation subject to District approval, the applicable model at time of bid, and shall furnish the following minimum capabilities:
    a. Quad-core processor
    b. 2.5 GHz processor speed
    c. 8 GB DDR4 3200 MHz RAM memory
    d. 1 TB solid state hard drive
    e. One Ethernet port, one serial port or detachable RS-232 adapter, and two USB ports
    f. 14-inch LCD flat panel display
    g. Minimum 8-hour battery charge during warranty period
    h. Latest operating system compatible with MPR software
2. The laptop computer wi-fi shall be capable of being disabled.
3. Software required for MPR testing, set-up, and diagnostics. Required software licenses shall be included. Software shall be provided on laptop and on separate storage media.
4. Test apparatus to verify MPR discrete I/O operation. Apparatus shall connect to the discrete I/O ports and shall activate the indicating LEDs to verify correct I/O operation.
5. Any other hardware and software, including cables, laptop carrying case, batteries, and computer software to provide complete and functional test equipment.

2.16 FACTORY TESTING

A. General: Testing of the MPR and DC buffer amplifier shall be in accordance with the requirements of Section 01 45 24, Testing Program Requirements.

B. Design Tests: The following design tests shall, as a minimum, be performed on one MPR including DC buffer amplifier and Operator Interface Panel. Where appropriate, the MPR, DC buffer amplifier, and Operator Interface Panel shall be tested as a unit. The testing shall be performed by a company or agency certified by the International Electric Testing Association (NETA):

1. Dielectric Strength: Tests per IEEE 37.90; and for the DC buffer amplifier input, also at voltages as required by these Specifications.

2. Surge Withstand Capability (SWC): Tests involving oscillatory and fast transient surges per IEEE 37.90.1.

3. Performance Verification Tests: Detailed procedures for the tests listed below shall be prepared and submitted for approval by the Engineer. Tests shall ascertain the proper functioning, accuracy and response time of the MPR including the DC buffer amplifier. At a minimum, tests shall include the following:

   a. Verification of the input voltage measurements accuracy and range.

   b. Verification of the input current measurements accuracy and range.

   c. Verification of the proper operation of protective functions.

   d. Verification of the proper operation of the load-measuring and auto-reclosing logic, including observance of user-defined parameters.

   e. Verification of the proper functioning of the self-diagnostic features, including trouble alarms, events storage and current and voltage data traces.

   f. Verification of the proper operation of user interfaces, including parameter updates through the operator interface panel, interrogation via Ethernet ports, and diagnostics via Ethernet ports.

   g. Verification of the correct operation of the MPR and DC buffer amplifier when the power supply voltage is varied within the specified operating range and confirmation of the proper functioning of the dual power supply with automatic changeover between the normal and backup power sources.

   h. Verification of the proper functioning of MPR inputs and outputs.

   i. Verification of proper communications between the MPR primary Ethernet communications port and the C02 panel PLC as described in Section 34 21 33, Control, Monitoring, and Display Panel. Tests shall verify required controls, indications, and data access functions.

   j. Verification of proper communications between the MPR secondary Ethernet/IP communications port and a host PC terminal. Tests shall verify required controls, indications, data viewing and download functions.

k. Verification that stored alarm and data trace information is retained in memory and can be readily accessed following a complete MPR primary and back-up power failure.

C. Production Tests: Detailed procedures for the tests listed below shall be prepared and submitted for approval by the Engineer. Tests shall be performed on complete MPR units, including the DC buffer amplifier and Operator Interface Panel. At a minimum, these tests shall include:

1. Confirmation of the correct calibration for current and voltage measurements of the DC buffer amplifier, and proper functioning of the MPR software.

2. Confirmation of the correct values for all default settings.

3. Confirmation of the proper operation of Operator Interface, RS-232, and Ethernet user interfaces.

4. Confirmation of the proper operation of the load-measuring logic, auto-reclosing logic, and protective functions, by the use of simulated fault conditions

5. Confirmation of the proper functioning of all I/Os of the MPR.

PART 3 – EXECUTION

Not Used

ATTACHMENT

FIGURE 1 - MPR RECLOSING LOGIC DIAGRAM

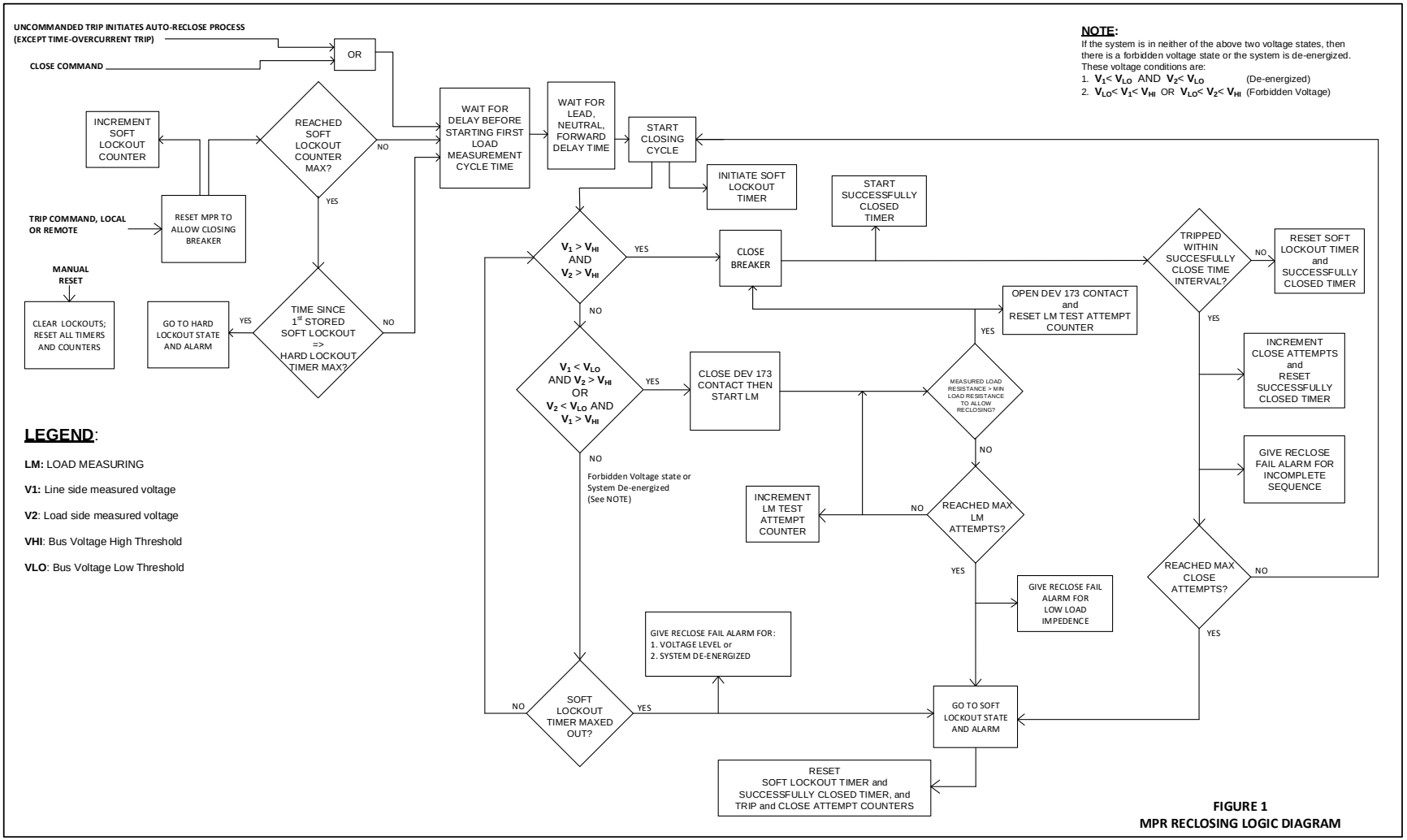


Figure 1 MPR RECLOSING LOGIC DIAGRAM

END OF SECTION 34 21 11

SECTION 34 21 12

INTEGRATED PROTECTION RELAY EQUIPMENT

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. System overview

B. Protection

C. Control

D. Automation

E. Communication and integration

F. Metering, monitoring, and reporting

G. Voltage and current input/output

H. User interface

I. Security

J. Power supply

K. Self-monitoring

L. Test and maintenance accessories

M. Spare parts

N. Factory testing

1.02 RELATED SECTIONS

A. Refer to the following Sections for requirements:

1. Section 01 33 00 Submittal Procedures
2. Section 01 33 23 Shop Drawings, Product Data, and Samples
3. Section 01 42 19 Reference Standards
4. Section 01 43 00 Quality Assurance
5. Section 01 45 00 Quality Control
6. Section 01 45 24 Testing Program Requirements

7. Section 01 78 23 Operation and Maintenance Data
8. Section 01 78 39 Contract Record Documents
9. Section 26 05 53 Identification Requirements
10. Section 27 13 01 Communication Cables and Related Equipment
11. Section 34 21 17 AC Switchgear (SF-6 Gas Insulated Type)
12. Section 34 21 18 AC Switchgear (Sealed Vacuum Type)
13. Section 34 21 33 Traction Power Control, Monitoring and Display Panel
14. Section 34 21 35 Emergency and Transfer Trip System
15. Section 34 21 40 DC Control Power System
16. Section 34 21 50 Common Materials and Methods for Traction Power
17. Section 34 21 75 Traction Power Facility System Factory Functional Testing
18. Section 34 21 80 Traction Power System Field Acceptance and Testing Requirements

1.03 MEASUREMENT AND PAYMENT

Separate measurement or payment will not be made for work required under this Section. All costs in connection with the work specified herein will be considered to be included with related items of Work in the Bid Schedule of the Bid Form, or incidental to the Work.

1.04 REFERENCES

A. Electronics Industries Association (EIA):

1. EIA/TIA 232_F Interface Between Data Terminal Equipment and Data Circuits

B. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE 802.3 Standard for Ethernet
2. IEEE C37.90 Standard for Relays and Relay Systems Associated with Electric Power Apparatus
3. IEEE C37.90.1 Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus

4. IEEE C37.90.3 Standard Electrostatic Discharge Tests for Protective Relays

5. IEEE C37.118 Synchrophasor for Power Systems - Measurements

6. IEEE C57.91 Guide for Loading Mineral-Oil-Immersed Transformers and Step-Voltage Regulators

7. IEEE C57.109 Guide for Liquid-Immersed Transformer Through-Fault-Current Duration

8. IEEE 1588 Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems

9. IEEE 1815 Standard for Electric Power Systems Communications - Distributed Network Protocol (DNP3)

C. International Electrotechnical Commission (IEC):

1. IEC 60255-21 Electrical Relays - Part 21: Vibration, Shock, Bump and Seismic Tests on Measuring Relays and Protection Equipment - Section One: Vibration Tests (Sinusoidal).

2. IEC 6068-2-18 Environmental testing – Part 2-18: Tests - Test R and Guidance: Water

3. IEC 61850 Power Utility Automation

4. IEC 62439-3 Industrial Communication Networks – High-availability Automation Networks - Part 3: Parallel Redundancy Protocol (PRP) and High-availability Seamless Redundancy (HSR)

1.05 SUBMITTALS

A. Refer to Section 01 33 00, Submittal Procedures; and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Submit the following to demonstrate compliance with applicable standards:

1. Where equipment or materials are specified to conform to the standards of organizations such as TIA/EIA, IEEE, and IEC submit evidence of such conformance. The label of the specified agency will be acceptable evidence.

2. As an alternative to the label or listing, submit a written certificate from an approved nationally recognized testing organization, adequately equipped and competent to perform such activities, stating that the items have been tested and that the units conform to the specified standards.

C. Submit as a minimum, the following:

1. Integrated Protection Relay (IPR) product data, providing name of manufacturer, model/brand/catalog number/activated optional features, and one copy each of the applicable standards for major components. Submittal shall be made in one package with a listing of the components arranged and identified in numerical sequence by article numbers within this Specification section.

2. Shop drawings including:

   a. IPR block diagram showing specified functional interfaces with external equipment including the AC switchgear, control and annunciator panel (C02), and communications equipment cabinet (C04), and emergency and transfer trip Cabinet (ETTC).

   b. IPR elementary control diagrams depicting logical functions or equipment including interfaces with the C02 panel, communications, and ETTC.

3. Required fusing, wiring, and other control circuit requirements.

4. Required IPR control and protective device settings and software configuration files for each relay installed.

5. Communications protocols demonstrating compatibility with Modbus TCP/IP or DNP3 communications protocols.

6. IPR installation requirements.

7. Factory design and production test procedures and data sheets.

8. Production Test Certifications.

9. Field test procedures and data sheets.

1.06 SYSTEM OVERVIEW

A. IPR equipment provide control and protection functions for AC switchgear located at the following BART 34.5 kV power distribution system facilities:

1. High Voltage Substations (HVS): HVSs receive power at 230 kV, 115 kV, or 60 kV utility transmission voltages at the facility primary side. HVS equipment consists of motorized high voltage air switches, high and medium voltage circuit breakers, a transformer, protection, control, and metering equipment, and station ancillary equipment. HVS convey 34.5 kV voltages from the facility secondary side for use in BART 34.5 kV sub-transmission system circuits.

2. Traction Power Substations (TPSS): TPSS are located along the track alignment at intervals varying between one-half and four miles. Each TPSS is supplied by two independent 34.5 kV sub-transmission system circuits, and converts the incoming AC power to 1,000 V (nominal) DC to power trains via the positive (contact rail) and negative (track running rail) DC distribution systems. TPSS equipment consists of medium voltage circuit breakers, traction power IEEE Circuit 31 type rectifier transformer-rectifier units, DC switchgear, AC vacuum switches, DC no-load break switches, protection and control equipment, and station ancillary equipment.

3. Switching Stations (SWS): SWSs receive power at 34.5 kV from HVS facilities for distribution to the BART 34.5 kV sub-transmission system. The sub-transmission system consists of two independent parallel feeder circuits that distribute power to traction power substations along the track alignment. SWS equipment consists of medium voltage switchgear, protection, control, and metering equipment; and station ancillary equipment.

4. Sectionalizing Stations (SS): Each 34.5 kV sub-transmission system power zone is normally supplied by a dedicated SWS. SSs located at the power zone boundaries enable power to be supplied from an adjacent power zone SWS in the event that the normal power supply unavailable. The SS 34.5 kV circuit breakers are normally open, but may be closed if needed to bring power from an adjacent zone's SWS. SS and SWS circuit breakers are interlocked to prevent parallel feeding from independent utility supply sources. SS equipment consists of medium voltage switchgear, protection and control equipment, and station ancillary equipment.

1.07 WARRANTY

A. The IPR shall include a ten-year warranty for material and workmanship defects. The warranty shall cover accidental customer-induced damage.

B. The manufacturer shall support a 72-hour turnaround on warranty repairs.

1.08 SERVICE

A. Provide no-cost technical support during the warranty period.

PART 2 – PRODUCTS

2.01 GENERAL

A. The IPR microprocessor-based relay shall provide a combination of functions including protection, monitoring, control, and automation, as described herein.

B. Environmental Immunity Requirements: The IPR shall be designed to operate without malfunctions under the following environmental and service conditions:

1. Environmental Requirements: The IPR shall be suitable for continuous operation over a temperature range of minus 40 degrees to 85 degrees Celsius, and shall meet the following requirements:

   a. Cold: IEC 60068-2-1, Severity Level: 16 hours at minus 40 degrees Celsius

   b. Damp Heat: IEC 60068-2-30, Severity Level: 25 degrees Celsius to 55 degrees Celsius, 6 cycles, Relative Humidity: 95 percent

   c. Dry Heat: IEC 60068-2-2, Severity Level: 16 hours at 85 degrees Celsius

2. Vibration:

   a. IEC 60255-21-1, Severity Level: Class 1 – Endurance

   b. IEC 60255-21-2, Severity Level: Class 1 – Shock Withstand, Bump, and Class 2 – Shock Response

   c. IEC 60255-21-3, Severity Level: Class 2 – Seismic Tests

3. Surge Withstand Immunity: IEEE C37.90.1, Severity Level: 2.5 kV oscillatory; 4.0 kV fast transient waveform.

4. Electrostatic Discharge Immunity: IEEE 37.90.3, Severity Level: 2, 4, 8 kV contact; 2, 4, 8, 15 kV air.

2.02 PROTECTION

A. IPR for HVS and TPSS shall meet the following:

1. The relay shall include protection functions as indicated on the Contract Drawings. Relays requiring functionalities described below shall provide characteristics hereunder.

2. Relays requiring differential protection shall include differential protection using at least five three-phase current inputs capable of monitoring four zones. Differential functions shall include:

   a. Restrained Differential Protection (87R): Include a single, three-phase low-impedance current differential element with adaptive restraint/operate slope characteristics.

   b. Negative Sequence Differential Protection (87N): Include negative-sequence differential protection for turn-to-turn fault detection within the transformer. The negative-sequence differential element shall detect turn-to-turn faults as low as two percent of the total winding.

c. Unrestrained Differential Protection (87U): The relay shall include unrestrained differential protection to provide rapid tripping for internal faults.

d. Relay shall be programmable to accommodate phase shifts and current transformations.

3. Combined Currents: The relay shall incorporate elements to provide overcurrent protection based on summation of currents from a minimum of four protection zones, implemented using combinations of three-phase CT inputs.

4. Overcurrent Protection: Relays requiring overcurrent protection shall include phase, negative, and zero-sequence overcurrent for both instantaneous and time-overcurrent elements. Torque control capability shall be provided for the inverse-time elements. Adaptive time-overcurrent elements shall be provided that allow operate quantity selection and programmable time-delay and pickup settings.

5. Directional Element: The relay shall include voltage polarized directional elements for phase and ground currents.

6. Earth Fault Protection: The relay shall provide three separate earth fault protection elements for the detection of ground faults in wye-connected windings.

7. External Faults: Upon detection by the relay of a fault external to the differential zones, the relay shall enter into a high-security mode to change the sensitivity of the relay (slope of differential) to avoid nuisance tripping.

8. Breaker Failure Protection: The relay shall include internal breaker failure protection with retrip functions for each of the terminals, and be selectable to accept external breaker failure protection. (call alarm “A0X trip circuit problem”)

9. Current Unbalance: The relay shall provide current unbalance elements for detecting phase current unbalance as compared to the average phase current.

10. Voltage Elements: The relay shall include three-phase over- and undervoltage elements as well as negative- and zero-sequence overvoltage elements.

B. IPR for SWS and SS shall meet the following:

1. The relay shall include protection functions as indicated on the Contract Drawings. Relays shall provide functionalities described below:

a. Phase, neutral, residual, and negative-sequence overcurrent elements (50P/50N/50G/50Q)

b. Phase, neutral, residual, and negative-sequence time-overcurrent elements (51P/51N/51G/51Q)

c. Over and undervoltage (59, 59G, 59Q, 27)

d. Power factor (55)

e. Synchronism check (25)

f. Residual overcurrent (50G/51G)

g. Breaker contactor failure

h. Line Voltage Check; The relay shall be programmable to allow closing when just one of line and load sides are energized, and shall block closing when both line and load sides of the circuit are either energized or de-energized.

2.03 CONTROL AND INDICATION

A. The relay shall accept commands to operate (CLOSE/OPEN) the associated circuit breaker:

1. Over an Ethernet connection to the relay.

2. Through optically isolated inputs.

3. From CLOSE/OPEN pushbuttons on the relay control panel.

B. The relay shall issue commands to operate (CLOSE/OPEN) the associated circuit breaker via dry contacts.

C. The relay shall provide CLOSED/OPEN indication status for the associated circuit breaker:

1. Over an Ethernet connection to the relay.

2. Through the facility backup control system via dry contacts.

D. The relay shall issue alarms, trouble indications, protective indications, and control functions and indications for the associated circuit breaker over an Ethernet connection to the RTAC PLC via the C04 panel. Convey relay trouble indications via hardwire connection to an IOM for transmittal to the C02 RTAC PLC via fiber optic media. Trouble indications shall alarm upon relay trouble or loss of power, and shall automatically trip the associated circuit breaker.

E. Provide under- and overvoltage elements for creating protection and control routines.

F. Transformer Inrush and Overexcitation Detection:

1. IPR of HVS and TPSS: The relay shall incorporate 2nd, 4th, and 5th harmonic blocking. In addition, 2nd and 4th harmonic restraint shall be provided. These restraint and blocking elements may be used independently, or in combination to prevent restrained differential element operation during inrush or overexcitation conditions. An independent fifth-harmonic element shall be included to warn of transformer overexcitation conditions. Wave-shape-based inrush detection addresses inrush conditions that contain low 2nd and 4th harmonic content.

2. IPR of SWS and SS: Not applicable.

G. The relay shall provide positive, negative, and zero-sequence voltage elements that can be logically configured for either under- or overvoltage applications.

H. Circuit breaker automatic transfer functions shall be provided through C02 RTAC PLC programming. Interlocking logic implemented through IPR relay programming is not acceptable.

2.04 AUTOMATION

A. The relay shall include 32 local control switches, 32 remote control switches, 32 latching switches, and programmable display messages in conjunction with a local display panel in the relay for use as internal relay program variables. The relay shall be capable of displaying custom messages.

B. The relay shall include programmable logic functions for user-configurable protection, monitoring, and control schemes. Logic shall have the ability to use relay elements, math functions, comparison functions, and Boolean logic functions.

C. The relay shall not need external auxiliary relays. Configuration and logic shall be realized in the relay software.

2.05 COMMUNICATION AND INTEGRATION

A. The relay shall provide capacity to support two physically independent Ethernet ports as follows:

1. Primary port: 100 Mbps primary physical port equipped with 100BaseFX send/receive ports with LC connectors for multimode fiber, to communicate with the C04 Panel Ethernet switch.

2. Secondary port: 100 Mbps secondary physical port equipped with 100BaseFX send/receive ports with LC connectors for multimode fiber, to communicate with remote terminals over the BARTNet Ethernet system via the C04 Panel Ethernet switch.

3. The secondary Ethernet port may be implemented using a serial port and fiber optic transceiver.

B. Synchrophasors. The relay shall provide high-accuracy, synchrophasor data that is compliant with the IEEE C37.118 synchrophasor data standard. The IEEE C37.118 synchrophasor data shall be supported on serial and Ethernet ports of the relay. The relay shall provide the capability to produce up to five phasor measurement unit (PMU) data configurations, and provide three selectable filter responses to measured PMU input signals. The relay shall provide the ability to alias the names of the phasors, analog quantities, and digital quantities.

C. Expandable Remote I/O: The relay shall send and receive real time data (RTD) or analog and binary data directly from remote I/O modules compatible with the relay. Any EIA 232 port may be configured for direct communication with the compatible remote I/O modules.

D. Terminal Communication: The relay shall allow communication from any ASCII terminal without proprietary software.

E. IRIG-B Time Input: The relay shall include an interface port for a demodulated IRIG-B time-synchronization input signal.

F. IEEE 1588 Precision Time Protocol: The relay shall support Precision Time Protocol version 2 (PTPv2), providing for high-accuracy timing over an Ethernet network.

G. IEC 61850 Ethernet Communications: The relay shall be capable of providing communications compliant to IEEE 1815 DNP3 and IEC 61850 protocol standards.

H. Simple Network Time Protocol (SNTP): The relay shall be capable of synchronizing the internal timekeeping to a network time source.

I. Web Server: The relay shall allow inspection of settings, metering reports, self-test reports, and configuration via an integrated web server.

J. Digital Relay-to-Relay Communications: The relay shall send and receive logic elements and analog and virtual terminal elements in each of two communications ports for dedicated relay-to-relay communications.

K. Provide following serial communications features:

1. Two independent EIA-232 serial ports

2. Full access to event history, relay status, and meter information from the communications

3. Settings and group switching password control

4. Synchrophasor data via C37.118 data format

5. Standard ASCII, Compressed ASCII, Fast Operate, Fast Meter, Fast SER and Enhanced MIRRORED BITS protocols (SEL)

2.06 METERING, MONITORING, AND REPORTING

A. The relay shall provide access to information for use in metering and data recording, including fundamental primary and secondary current and voltage magnitudes and angles; RMS voltage and current; differential metering showing the operating and restraint currents for each three-phase differential element; and the reference current.

B. The relay shall monitor and retain the following instantaneous values:

1. Fundamental power system frequency voltages.

2. Fundamental voltages compensated to account for delta/wye-transformer and PT configurations.

3. Positive, negative, and zero-sequence currents and voltages.

4. RMS voltages and currents shall include fundamental plus total harmonic distortion (THD) including measurable harmonics to the 16th harmonic.

5. Currents measured at the fundamental frequency of the power system, with transformer phase-compensation applied.

6. Power Factor: A, B, C, 3P single and three-phase power factor, leading or lagging.

C. The relay shall provide the following metering capabilities:

1. Power and energy metering quantities shall be calculated using fundamental voltage and current measurements; S = MVA, P = MW, Q = MVAR.

2. For IPR of HVS and TPSS, differential metering shall include:

a. Operate current magnitude and restraint current magnitude (both in per unit).

b. Harmonic quantities representing the effective harmonic content of the operate current used for harmonic blocking and harmonic restraint.

3. Demand/peak metering shall include thermal or rolling interval demand.

4. Metering reports shall include fundamental phase and real and reactive power, per phase voltage magnitude, angle, and frequency.

D. Synchrophasor Data Recording: Provide 120-second synchrophasor data recording stored in nonvolatile memory using IEEE C37.118 binary data format.

E. Event Reporting:

1. IPR for HVS and TPSS: The relay shall automatically record disturbance events as long as three seconds at 8 kHz sampling rate and 24 seconds at 1 kHz sampling rate. Events shall be stored in nonvolatile memory. The relay shall provide event reports at 8 kHz in COMTRADE data format, eight samples per cycle, and four samples per cycle.

2. IPR for SWS and SS: Provide, at a minimum, 15 cycle-length (up to 77 reports) or 64-cycle length (up to 19 reports) with 4 or 16 samples/cycle resolution.

F. Sequential Events Recorder (SER):

1. IPR for HVS and TPSS: Provide a SER report that stores the latest 1000 entries of at least 250 monitored points.

2. IPR for SWS and SS: Provide a SER report that stores the latest 1000 entries.

G. Transformer Thermal Monitor:

1. IPR for HVS and TPSS: Provide a transformer thermal monitor based on IEEE C57.91. The model shall include capability for entering known transformer thermal constants as well as default constants. Three loss-of-insulation-life alarms shall be provided, including loss-of-life per day, total loss-of-life, and insulation aging factor. Up to 12 temperature inputs shall be accommodated by the relay from either RTD or from IEC 61850 Goose Messaging Remote Analog Quantities.

2. IPR for SWS and SS: None.

H. Through-Fault Event Monitor:

1. IPR for HVS and TPSS: Provide the capability of reporting fault current level, duration, and date/time for overcurrent events through the differential protection zone. Through-fault monitoring shall provide accumulated through-fault levels, number of through-faults and the total consumed through-fault capacity of the transformer, based on IEEE C57.109.

2. IPR for SWS and SS: None.

I. Fault Identification Logic:

1. IPR for HVS and TPSS: The relay shall determine, on a per-terminal basis, which phase(s) was involved in a fault for which the transformer tripped. Faulted phase identification is based on current inputs from wye-connected CTs.

2. IPR for SWS and SS: None.

2.07 VOLTAGE AND CURRENT INPUTS/OUTPUTS

A. Provide sufficient optoisolated level-sensitive analog inputs necessary to support relay functions, including each current transformer winding, earth fault current, and potential transformer input.

B. Current transformer inputs, 5A secondary:

1. IPR for HVS and TPSS: The relay shall accept CTs from different classes and a ratio mismatch of 35:1 as indicated. Measuring quantities shall be on a phase-segregated basis and not from summation CTs.

2. IPR for SWS and SS: Four 5A AC current inputs, minimum.

C. Potential transformer inputs, 300V maximum:

1. The relay shall accept potential transformer inputs as indicated.

D. Provide high current, high speed outputs necessary to support relay functions.

E. Provide dedicated inputs and outputs for each relay function. Provide 30 percent spare of inputs and outputs as a minimum.

F. Provide independently operated breaker open/close switches or pushbuttons with following characteristics:

1. Indicating lamps.

2. Device close switch with a programmable time delay of 1 to 20 seconds minimum between switch actuation and initiating circuit breaker closing.

3. Sealable guards to prevent unauthorized operation and protection from inadvertent operation.

4. Switch contacts shall include solid-state protection to eliminate arcing damage and prolong contact life.

5. Switches and breaker status lamps shall be functional regardless of the relay status.

G. Provide digital and analog outputs necessary to drive C02 panel meters, as indicated in the Contract Drawings. Include two spare inputs and two spare outputs.

2.08 USER INTERFACE

A. Front panel: provide as a minimum:

1. LCD screen with active area 3.2 inches by 3.2 inches, minimum.

2. 24 tri-color LED target indicators

3. 12 control pushbuttons with indicating LEDs for local control functions

4. Target and pushbutton indication custom configurable with easily changed slide-in labels.

B. Provide LCD control through navigation pushbuttons, automatic messages the relay generates, and user programmable display points.

C. LCD display: A rotating display shall scroll through any active, nonblank display points. If none are active, the relay shall scroll through displays of the differential operating and restraint quantities and the primary current and voltage values. Each display shall remain for five seconds before the display continues scrolling. Any message generated by the relay because of an alarm condition shall take precedence over the rotating display.

2.09 SECURITY

A. Provide following security levels:

1. Level one shall allow viewing of relay information, parameters, and settings. Level one does not require password security for viewing only.

2. Level two, requiring password protected security, shall allow the use to change parameters and settings, as well as download SER and other stored relay data.

B. Relay security authorizations shall be accessed through the relay front panel user interface or remotely through the secondary Ethernet port.

C. A physical key type security system using a USB key or other means is not acceptable.

2.10 POWER SUPPLY

A. Power supply: 125/250 VDC

B. Absolute range: 83 to 300 VDC

2.11 SELF MONITORING

A. The IPR relay shall initiate a self-test on power-up, and shall continuously monitor internal operations using a ‘watchdog’ function. The watchdog function shall assert a trouble alarm indicated locally at the front panel user interface if the control routine fails to toggle the watchdog function for more than one second. The IPR shall be provided with an output relay contact and an alarm signal available at the IPR’s primary Ethernet port. Alarms shall be stored in the SER.

B. Relay internal diagnostics shall be accessed through the operator keypad and the secondary Ethernet/IP network maintenance port connection.

2.12 TEST AND MAINTENANCE ACCESSORIES

A. Furnish three complete sets of special tools and test equipment, each set comprising hardware and software necessary for field testing, diagnostics, maintenance and repair of the IPR relay. At a minimum, each set of test apparatus shall include:

1. Laptop computer: Latest applicable model at time of bid, with the following minimum capabilities:

   a. Quad-core processor

   b. 2.5 GHz processor speed

   c. 8 GB DDR3L 1600 MHz RAM memory

   d. 1 TB solid state hard drive

   e. DVD +/- RW drive

f. One Ethernet, one RS-232 serial, and two USB ports

g. 17-inch LCD flat panel display

h. Minimum 8-hour battery charge during warranty period

i. Latest operating system compatible with IPR software

j. The laptop computer wi-fi shall be capable of being disabled.

2. Laptop carrying case, batteries, and computer software to provide complete and functional test equipment.

3. Software required for relay set-up, testing, and diagnostics. Required software licenses shall be included. Software shall be provided on laptops and on separate storage media.

4. Cable connecting hardware needed to connect laptops with the IPR, using a USB connector at the computer end of the connection.

2.13 SPARE PARTS

A. For each ten IPR relays furnished, provide one spare IPR relay.

2.14 FACTORY TESTING

A. General: Testing of the IPR, and operator interface shall be in accordance with the requirements of Section 01 45 24, Testing Program Requirements.

B. Design Tests: Provide certification from an independent testing agency certified by the International Electric Testing Association (NETA) that the IPR relay meets test requirements specified herein. Tests shall include, but are not limited to the following:

1. Dielectric Strength: Tests per IEEE 37.90.

2. Surge Withstand Capability (SWC): Tests involving oscillatory and fast transient surges per IEEE 37.90.1.

3. Performance Verification Tests

a. Tests shall ascertain the proper functioning, accuracy and response time of the IPR relay. At a minimum, tests shall verify the following:

1) Input voltage and current measurements (accuracy and range verification).

2) Isolation and voltage and current ratings of relay inputs and outputs.

3) Specified electrical withstands.

4) Operation of protective functions.

5) Functioning of the self-diagnostic features, including trouble alarms, events storage, and current and voltage data traces.

6) Operation of user interfaces, including parameter updates through the operator interface panel and interrogation/diagnostics via the Ethernet ports.

7) Function of IPR relay inputs and outputs.

8) Communications over the IPR primary Ethernet communications port using communications protocols described in Section 34 21 33, Control, Monitoring, and Display Panel. Test to show that required controls, indications, and data access function correctly.

9) Communications between the IPR secondary maintenance access Ethernet communications port and a host PC terminal to verify required indications, settings adjustments, and data viewing and download function.

10) Verify that stored event recordings remain available following a relay power failure.

11) Operation of user interface, RS-232, and Ethernet user interfaces.

4. Design test certifications may be considered in lieu of design tests for acceptance by the Engineer for design tests performed on equipment identical to that proposed.

C. Production Tests: Production tests certifications shall show proper performance of each IPR relay provided. Certifications shall confirm correct:

1. Calibration for relay current and voltage measurement functions, and correct function of the relay software.

2. Operation of user interface, RS-232, and Ethernet user interfaces.

3. Voltage and current ratings of relay inputs and outputs.

4. Isolation of relay inputs.

D. Coordinate and perform factory testing per requirements of Specifications Section 34 22 75, Traction Power System Facility Functional Factory Testing.

PART 3 – EXECUTION

3.01 FIELD TESTING

A. Coordinate and perform field testing per requirements of Specifications Section 34 22 80, Traction Power System Field Acceptance Testing.

END OF SECTION 34 21 12

SECTION 34 21 14

ENERGY AND POWER QUALITY METER

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Reference standards

B. System overview

C. Design features and Equipment Characteristics

D. Input/Output requirements

E. Measurement Capability

F. Power supply

G. Software computational capability

H. Security

I. Factory testing

J. Field testing

1.02 RELATED SECTIONS

A.	Section 01 33 00	Submittal Procedures
B.	Section 01 33 23	Shop Drawings, Product Data and Samples
C.	Section 01 42 19	Reference Standards
D.	Section 01 43 00	Quality Assurance
E.	Section 01 45 00	Quality Control
F.	Section 01 45 24	Testing Program Requirements
G.	Section 01 78 39	Project Record Documents
H.	Section 20 40 13	Identification for Facility Services
I.	Section 27 13 01	Communication Cables and Related Equipment
J.	Section 34 21 33	Traction Power Control, Monitoring, and Display Panel and Related Equipment

K. Section 34 21 75 Traction Power Facility Factory Functional Testing

L. Section 34 21 80 Traction Power System Field Acceptance Testing

1.03 MEASUREMENT AND PAYMENT

A. Separate measurement or payment will not be made for work required under this Contract Specifications Section. All costs in connection with the work specified herein will be paid for as part of the Contract lump sum price for the related item of work as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCE STANDARDS

A. American National Standards Institute (ANSI):

1. ANSI C12.20 Electricity Meters – 0.1, 0.2, and 0.5 Accuracy Classes.

B. International Electrotechnical Commission (IEC):

1. IEC 60068-2-2 Environmental Testing – Part 2-2
2. IEC 61000-4-30 Electromagnetic Compatibility (EMC) Part 4-30: Testing and Measurement Techniques – Power Quality Measurement Methods
3. IEC 61010-1 Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use – Part 1: General Requirements
4. IEC 62052 11 Electricity metering equipment (AC) general requirements, tests and test conditions
5. IEC 62053-23 Electric Metering Equipment (AC) – Particular Requirements – Part 23. Static Meters for Reactive Energy (Classes 2 and 3)

C. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE 37.90 Standard for Relays and Relay Systems Associated with Electric Power Apparatus
2. IEEE C37.90.1 Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
3. IEEE C37.118 Synchrophasor Data for Power Systems
4. IEEE 519 Recommended Practice and Requirements for Harmonic Control in Electric Power Systems

5. IEEE 1588 Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems

6. IEEE 1815 Electric Power Systems Communications-Distributed Network Protocol (DNP3)

D. Telecommunications Industry Association (TIA):

1. EIA/TIA-232-F Interface Between Data. Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange

2. EIA/TIA-485-A Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems

E. Underwriters Laboratories (UL):

1. UL 508 Standard for Industrial Control Equipment

2. UL 61010B-1 Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use – Part 1. General Requirements

1.05 ABBREVIATIONS AND ACRONYMS

A.	AC	Alternating Current
B.	DC	Direct Current
C.	Hz	Hertz
D.	kV	Kilovolts
E.	kWhr	Kilo Watt Hour
F.	kVAh	Kilo Volt Amp Hour
G.	kVARh	Kilo Volt Amp Reactive Hour
H.	LV	Low Voltage
I.	L-L	Line to Line
J.	L-G	Line to Ground
K.	ms	milli-seconds
L.	Meter	Energy and Power Quality Meter
M.	NETA	International Electric Testing Association

N. PMS Performance Measurement System

O. RS-232 Recommended Standard 32 for Serial Communication

P. RS-485 Recommended Standard 32 for Serial Communication

Q. V Volts

1.06 SUBMITTALS

A. Refer to Contract Specifications Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Submit the following to demonstrate compliance with applicable standards:

1. Where equipment or materials are specified to conform to the standards of organizations such as IEEE and ANSI submit evidence of such conformance. The label of the specified agency will be acceptable evidence.

2. As an alternative to the label or listing, submit a written certificate from an approved nationally recognized testing organization, adequately equipped and competent to perform such activities, stating that the items have been tested and that the units conform to the specified standards.

3. Design tests: Submit test certifications showing correct equipment characteristics and function as follows:

    a. Surge withstand capability tests.

    b. Performance verification tests:

        1) Input voltage and current measurements (accuracy and range verification).

        2) Isolation, voltage, and current ratings of meter inputs and outputs.

        3) Operation of all measurement functions.

        4) Functioning of the self-diagnostic features, including trouble alarms, events storage and current and voltage data traces.

        5) Operation of all user interfaces, including parameter updates through the operator interface panel and interrogation/diagnostics via the Ethernet ports.

        6) Function of all inputs and outputs.

7) Communications over primary Ethernet communications port using specified Contract communications protocols described in Contract Specifications Section 34 21 33, Traction Power Control, Monitoring, and Display Panel and Related Equipment. Tests shall show that all required controls, indications, and data access functions operate correctly. Tests shall show that communications between the meter secondary maintenance access Ethernet communications port and a host PC terminal to verify all required, indications, settings adjustments, and data viewing and download functions.

8) Verify that stored event recordings remain available following a meter power failure.

9) Operation of user interface, EIA-485, EIA-232, and Ethernet user interfaces.

4. Design test certifications may be considered in lieu of design tests for acceptance by the Engineer for design tests performed on equipment identical to that proposed.

C. Production Tests: Submit test certifications to show proper performance of each meter provided. Certifications shall confirm correct:

1. Calibration for current and voltage measurement functions, and correct function of the meter software.

2. Operation of user interface, RS-232, RS-485, and Ethernet user interfaces.

3. Voltage and current ratings of meter inputs and outputs.

4. Isolation of inputs.

1.07 SYSTEM OVERVIEW

A. The meter is utilized at BART switching stations and traction power substations in which the electrical energy is supplied to the BART 34.5 kV system by the utility company and distributed over BART 34.5 kV power distribution system. These meters are primarily used to:

1. Help verify the billing by utility company and provide backup for in-house energy consumption information.

2. Monitor the power quality of the incoming utility power supply.

3. Assess power quality in BART’s 34.5kV subtransmission system.

1.08 WARRANTY

A. The meter shall include a two-years minimum warranty for all material and workmanship defects.

B. The manufacturer shall support a 72-hour turnaround on all warranty repairs.

1.09 SERVICE

A. Provide no-cost technical support during the warranty period.

PART 2 – PRODUCTS

2.01 DESIGN FEATURES

A. General Provisions

1. All setup parameters required by the meter shall be stored in nonvolatile memory and retained in the event of a control power interruption.

2. The meter may be applied in 4-wire wye, 3-wire wye, 3-wire delta, direct delta, and single-phase systems.

B. Operating Temperature

1. –40° to +85°C (–40° to +185°F)

2. Conform to IEC 60068-2-2

C. Dielectric and Surge Withstand Capability

1. Meter shall meet requirements as follows:

   a. IEEE C37.90.1: Severity Level: 2.5 kV oscillatory, 4 kV fast transient

   b. IEEE C12.20: Severity Level: 15 V/m

D. Current and Voltage Inputs

1. The meter shall have no less than 4 voltage inputs and 5 current inputs.

2. The meter shall be able to withstand 1500 VAC RMS continuously without damaging the device.

3. The meter shall support nominal current ratings of 1A, 2A, 5A, 10A, and 20A and an overcurrent rating of 500A for 1s (5A nominal model) or 200A for 1s (1A nominal model).

E. Measurement Capabilities:

1. The meter shall provide at minimum the following voltage values:

   a. Voltage L-L per-phase.

b. Voltage L-L 3-phase average.

c. Voltage L-N per-phase.

d. Voltage 3-phase average.

e. Voltage percentage unbalanced.

2. The meter shall provide at minimum the following current values:

a. Current per-phase, neutral (measured).

b. Current 3-phase average.

c. Current percentage unbalanced.

3. The meter shall provide at minimum the following power values:

a. Real power (per-phase, 3-phase total).

b. Reactive power (per-phase, 3-phase total).

c. Apparent power (per-phase, 3-phase total).

d. Power factor - true (per-phase, 3-phase total).

e. Power factor - displacement (per-phase, 3-phase total).

4. The meter shall provide at minimum the following energy values:

a. Accumulated energy (real kWh, reactive kVARh, apparent kVAh) (signed/absolute).

b. Incremental energy (real kWh, reactive kVARh, apparent kVAh) (signed/absolute).

c. Conditional energy (real kWh, reactive kVARh, apparent kVAh) (signed/absolute).

d. Reactive energy by quadrant.

5. The meter shall provide a minimum and maximum value for any measured parameter.

6. The meter shall be capable of deriving values for any combination of measured or calculated parameter, using the following arithmetic, trigonometric, and logic functions (or equivalent PLC capabilities):

a. Arithmetic functions: division, multiplication, addition, subtraction, power, absolute value, square root, average, max, min, RMS, sum, sum-of-squares, unary minus, integer ceiling, integer floor, modulus, and exponent.

b. Trigonometric functions: COS, SIN, TAN, ARCCOS, ARCSIN, ARCTAN, LN, LOG10.

c. Logic functions: =, =>, <=, <>, <, >, AND, OR, NOT, IF

d. Thermocouple linearization functions: Type J, Type K, Type R, Type RTD, Type T.

e. Temperature conversion functions: C to F, F to C.

F. Demand

1. The meter shall be able to provide min and max demand, present demand interval, running average demand, and predicted demand on multiple demand channels.

2. The meter shall be able to perform multiple accepted demand calculation methods including block, rolling block, and thermal demand with user-programmable demand period length.

G. Accuracy

1. The meter shall meet ANSI C12.20 accuracy class 0.1.

2. The meter shall provide 4-quadrant metering.

H. Sampling

1. The meter shall sample at 512 samples/cycle.

2. The meter shall be able to perform high speed sag/swell detection of voltage disturbances on a cycle-by-cycle basis, providing the duration of the disturbance, the minimum, maximum, and average value of the voltage for each phase during the disturbance. Disturbances less than one cycle in duration can be detected.

I. Logging

1. The meter shall have 512 logging channels.

2. The meter shall have at least 1 GB of storage.

3. The meter shall be capable of capturing 10,000 event reports and 130,000 voltage events.

4. The meter shall have non-volatile memory.

5. The meter shall have a time-stamped event log with the following features:

a. The number of records in the log is programmable.

b. Each event is recorded with the date and time of the event and the cause and effect of the event.

c. All events relating to setpoint activity, relay operation and self-diagnostics is recorded in the event log.

d. Time stamps are synchronized to within 100 ms between devices on the same serial communications medium.

e. Minimum event recording response time is 0.5 cycles (8.3ms 60Hz) for high-speed events and 1 second for other events.

f. The priority of setpoint events is programmable.

6. The meter shall be able to log any parameter in the meter including min/max and waveforms.

J. Alarming

1. The meter shall have setpoint driven alarming capability.

2. The meter shall have millisecond timestamp resolution on alarm entries.

3. The meter shall be able to operate relays on alarm conditions.

4. The meter shall be able to initiate data-log captures on alarm conditions.

5. The meter shall be able to control digital output relays in an AND or an OR configuration, using pulse mode or latch mode operation, for control and alarm purposes.

6. The meter shall be able to combine any logical combination of any number of available setpoint conditions to control any internal or external function or event.

K. Communications

1. The meter shall support:

a. Ethernet, EIA-485, EIA 232, communications simultaneously and independently.

b. Modbus RTU/TCP, TCP/IP, MIRRORED BITS communications, DNP3 Serial and LAN/WAN, IEC 61850, IEEE C37.118.2, Telnet, SNTP, and FTP communications protocols.

L. I/O Characteristics

1. Provide following I/O configuration options:

a. 4 Digital Inputs and 4 Digital Outputs (solid-state or electromechanical).

b. 4 Analog Outputs 4 Digital Solid-State Outputs.

2. AC Voltage and Current Inputs

a. 300 VL–N, 520 VL–L continuous 600 VL–N; 1039 VL–L for 10 seconds.

b. 20 A continuous, per UL 61010 500 A for 1 second.

3. Output Contacts

    a. 250 Vac, 30 Vdc, 3 A resistive.

    b. Optional solid state:

        1) 250 Vdc or Peak ac maximum; Current: 100 mA maximum

4. Digital inputs and analog outputs shall be optically isolated

M. Provide 800x480 color touchscreen Display

N. Security

1. Meter shall provide four password levels controlling access to metering data.

2. Meter shall provide port security settings allowing three permission levels allow controlled read and write access to the ports.

3. Meter shall verify the authenticity and integrity of firmware files during upgrades by using a checksum and cryptographic signature. Any mismatch during a firmware upgrade shall cause the meter to reject the file.

4. The security password shall enable programming through a computer or the front panel.

O. Field Programmability

1. The meter shall be field programmable as follows:

    a. Basic parameters: Voltage input scale, voltage mode (Wye, Delta, single phase), current input scale, auxiliary input and output scales, and communications setup parameters are programmable from the front panel.

    b. All basic parameters described above, plus additional setpoint/relay and data log setup parameters shall be able to be programmed via the communications port using a portable or remotely located computer terminal.

    c. Custom configuration of all operating parameters shall be possible through a graphical, flexible programming language.

    d. Programmability shall be sectioned such that when the meter is sealed, the meter shall still be configurable to an extent that does not affect the accumulation of revenue metering related data.

P. Power Quality

1. Without the use of separate software, the meter shall be able to evaluate power quality statistically in accordance with IEC 61000-4-30 Class A Edition 2.

2. The meter shall be certified by a third party as compliant with IEC 61000-4-30 class A, Edition 2.

3. Without using separate software, the meter shall determine statistical indicators of power quality parameters that include but are not limited to flicker, dips and swells, harmonics, and inter-harmonics.

4. Without the use of separate software, the meter shall make available the statistical indicators of power quality on the front panel display, or via communications over any supported protocol (ION, Modbus RTU, Modbus TCP, DNP 3.0), or via an analog transducer interface.

5. Without the use of separate software, the meter shall monitor the value of any statistical indicator of power quality (present, predicted, average or otherwise manipulated value) with an absolute or relative setpoint. When such setpoint is exceeded, the relay shall be able to be programmed to issue an alert of the condition via Ethernet or through analog or digital outputs.

6. The meter shall support symmetrical components.

Q. Transients

1. The meter shall provide sub-cycle voltage transient detection at a minimum of 1024 samples/cycle.

2. The meter shall be able, at a minimum, to perform 17 microsecond transient captures at 60Hz.

R. Waveform Capture

1. The meter shall be able to perform, at a minimum, 1024 or 512 samples/cycle waveform capture recording.

2. The meter waveform recorder shall have the following features:

   a. Able to record a digitized representation of any phase voltage or current signal with no dead time between such recordings, and the ability to trigger multiple such recordings in continuous succession, and at different resolutions simultaneously.

   b. Enabled and triggered manually or through internal operating conditions, including periodic timer or setpoint activity.

   c. High speed triggering is supported.

   d. The number of records (depth) of each data recorder, and the overflow conditions (stop-when-full or circular) is programmable. The relay overflow procedure shall to set to ‘circular’ as a default.

S. Power Supply

1. The meter shall be capable of operating from a nominal 125 V DC power supply.

T. The meter shall be SEL 735-3 (Advanced) or equivalent model approved by the Engineer.

2.02 FACTORY TESTING

A. General: Testing of the meter shall be in accordance with the requirements of Contract Specifications Section 01 45 24, Testing Program Requirements.

B. Design Tests: Provide certification from an independent testing agency certified by NETA that the meter meets test requirements specified herein. Tests shall include, but are not limited to the following:

1. Dielectric and surge withstand capability as required in Article 2.01C.

2. Performance Verification Tests

   a. Input voltage and current measurements (accuracy and range verification).

   b. Isolation and voltage and current ratings of meter inputs and outputs.

   c. Specified electrical withstands.

   d. Operation of all measurement functions.

   e. Functioning of the self-diagnostic features, including trouble alarms, events storage and current and voltage data traces.

   f. Operation of all user interfaces, including parameter updates through the operator interface panel and interrogation/diagnostics via the Ethernet ports.

   g. Function of all inputs and outputs.

   h. Communications over primary Ethernet communications port using specified Contract communications protocols described in Contract Specifications Section 34 21 33, Traction Power Control, Monitoring, and Display Panel and Related Equipment. Tests shall show that all required controls, indications, and data access functions operate correctly. Tests shall show that communications between the meter secondary maintenance access Ethernet communications port and a host PC terminal to verify all required, indications, settings adjustments, and data viewing and download functions.

   i. Verify that stored event recordings remain available following a meter power failure.

   j. Operation of user interface, RS-232, and Ethernet user interfaces.

3. Design test certifications may be considered in lieu of design tests for acceptance by the Engineer for design tests performed on equipment identical to that proposed.

C. Production Tests: Perform the following confirming correct function of each meter.

1. Calibration for current and voltage measurement functions, and correct function of the meter software.

2. Operation of user interface, RS-232, RS-485, and Ethernet user interfaces.

3. Voltage and current ratings of inputs and outputs.

4. Isolation of inputs.

D. Coordinate and perform factory testing per requirements of Contract Specifications Section 34 21 75, Traction Power Facility Factory Functional Testing.

PART 3 – EXECUTION

3.01 FIELD TESTING

A. Coordinate and perform field testing per requirements of Contract Specifications Section 34 21 80, Traction Power System Field Acceptance Testing.

END OF SECTION 34 21 14

SECTION 34 21 16

34.5 kV VACUUM FAULT INTERRUPTER SWITCHGEAR

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. General Requirements

B. AC Vacuum Fault Interrupter Switchgear

C. Integrated Protection Relay

D. 125 Volt DC Control Power

E. 120 Volt AC Power

F. Instrument Transformers

G. Terminations

H. Separable Insulated Connectors

I. Factory Testing

J. Traction Power System Field Acceptance Testing

1.02 RELATED SECTIONS

A. Refer to the following Sections for requirements:

1. Section 01 33 00 Submittal Procedures
2. Section 01 33 23 Shop Drawings, Product Data, and Samples
3. Section 01 45 24 Testing Program Requirements
4. Section 01 78 23 Operation and Maintenance Data
5. Section 01 79 00 Demonstration and Training
6. Section 01 78 44 Spare Parts and Maintenance Materials
7. Section 34 21 01 General Requirements for the Traction Power System
8. Section 34 21 07 Prefabricated Portable Substations
9. Section 34 21 11 Multi-Function Protection Relay Equipment
10. Section 34 21 33 Control, Monitoring and Display Panel

11. Section 34 21 40 DC Control Power System
12. Section 34 21 50 Common Materials and Methods for Traction Power
13. Section 34 21 80 Traction Power System Field Acceptance Testing
14. Section 34 22 23 Traction Power Cables

1.03 MEASUREMENT AND PAYMENT

A. Measurement: Vacuum fault interrupter switchgear units will be measured for payment per individual unit that is fabricated, factory tested, delivered to site, installed and field functioning tested in accordance with the Contract Documents.

B. Payment: Vacuum fault interrupter switchgear units will be paid for at the Contract unit price per each individual unit as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE C37.60 High-Voltage Switchgear and Controlgear – Part III: Automatic Circuit Reclosers and Fault Interrupters for Alternating Current Systems Up to 38 kV.
2. IEEE C37.74 Standard Requirements for Subsurface, Vault, and Pad-Mounted Load-Interrupter Switchgear and Fused Load-Interrupter Switchgear for Alternating Current Systems up to 38 kV.
3. IEEE C57.12.28 Standard for Pad-Mounted Equipment—Enclosure Integrity.
4. IEEE C57.12.29 Standard for Pad-Mounted Equipment—Enclosure Integrity for Coastal Environments.
5. IEEE C37.90 Standard for Relays and Relay Systems Associated with Electric Power Apparatus.
6. IEEE C37.90.1 Standard for Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems Associated with Electric Power Apparatus.
7. IEEE C57.13 Standard Requirements for Instrument Transformers.

B. National Electrical Manufacturers Association (NEMA):

1. NEMA C12.11 Instrument Transformers for Revenue Metering 10 kV BIL through 350 kV BIL (0.6 kV NSV through 69 kV NSV).

C. National Electrical Safety Code (NESC):

1. IEEE/ANSI C2 National Electrical Safety Code.

D. National Fire Protection Association (NFPA):

1. NFPA 70 National Electrical Code.

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures; and Section 01 33 23, Shop Drawings, Product Data, and Samples for submittal requirements and procedures.

B. Product Data: Submit product data for components specified herein.

C. Shop Drawings:

1. Provide design drawings for the 34.5 kV switchgear and associated devices, including equipment layouts, circuit breaker control schematics, and wiring diagrams.

2. Include VFI mounting, cable entry, and conduit design for cable connections to the rectifier transformer.

3. Separable insulated connector section details for materials and assembly construction. Connector and cable terminators showing cross section and installation details.

D. Protective relay settings software, and device ladder logic diagrams communications interfaces with C02 Panel PLC, software, and ladder logic diagrams.

E. Test plan and procedures for factory testing.

F. Test report for factory testing.

G. Operation and Maintenance Manuals: Provide operation and maintenance manuals in accordance with Section 01 78 23, Operation and Maintenance Data.

H. Equipment and software configuration control logs.

1.06 QUALITY ASSURANCE AND SUPPLIER QUALIFICATIONS

A. Electrical components, devices, and accessories shall be listed and labeled in conformance with NFPA 70, Article 100.

B. The manufacturer of the 34.5 kV vacuum fault interrupter switchgear shall have a minimum of 5 years of successful and proven transit, industrial, or utility experience of providing equipment similar to the one specified herein.

C. Auxiliary equipment, devices and components comprising the AC switchgear shall be proven standard products, or equivalent to the standard products of manufacturers engaged in the production of such equipment, devices, and components for at least the past 5 years.

1.07 DELIVERY, STORAGE AND HANDLING

A. Equipment shall be weatherproofed for shipment. Connection openings shall be closed to prevent entrance of foreign material during shipment and storage.

B. Equipment shall be handled and stored in conformance with manufacturer's instructions. One copy of these instructions shall be included with the equipment at time of shipment.

1.08 SPARE PARTS, TEST EQUIPMENT AND TOOLS

A. Mandatory Spare Parts: For each vacuum fault interrupter delivered, furnish the following mandatory spare parts required to maintain and operate the 34.5 kV vacuum fault interrupter switchgear with the requirements of Section 01 78 44, Spare Parts and Maintenance Materials.

1. Two integrated protection relays.

2. One vacuum fault interrupter.

3. 10 percent spares of fuses, indication lights, and control power circuit breakers.

B. Recommended Spare Parts: Provide a recommended list of spare parts required to maintain and operate the vacuum fault interrupter switchgear in accordance with the requirements of Section 01 78 44, Spare Parts and Maintenance Materials.

PART 2 – PRODUCTS

2.01 GENERAL REQUIREMENTS

A. The Supplier shall furnish, factory test, and provide field test support for the following major equipment/devices, and necessary accessories for installation, as specified below:

1. AC vacuum fault interrupter switchgear.

2. Integrated protection relay (IPR).

3. Instrument transformers.

2.02 AC VACUUM FAULT INTERRUPTER SWITCHGEAR

A. Supplier shall provide a self-contained outdoor-type three-phase 35 kV AC nominal vacuum fault interrupter (VFI) switchgear with 38 kV AC maximum voltage and 150 kV BIL suitable for use with a rectifier transformer. VFI continuous current rating shall be 600 A with current interrupting capability of 3 cycles, 12.5 kA symmetrical, and 20 kV asymmetrical. VFI switchgear shall include visible break switch window and motor operator.

B. VFI switchgear shall meet IEEE C37.74.

C. VFI shall be a sealed insulation system, not using oil.

D. VFI shall use resettable interrupter controls and shall not use fuses.

E. VFI shall include remote close, remote trip, alarm indications, and shall indicate open and close status at the C02 Panel and OCC.

F. VFI shall use an IPR as specified in 34 21 12, Integrated Protection Relay Equipment.

G. VFI switchgear shall be housed in a portable substation trailer as specified in Section 34 21 07, Prefabricated Portable Substations and shall meet requirements for underground devices in IEEE C57.12.28 and IEEE C57.12.29.

H. VFI switchgear shall be mounted to the 34.5 kV switchgear and rectifier transformer trailer tongue as shown in the Contract Drawings.

2.03 INTEGRATED PROTECTION RELAY

A. For each 34.5 kV VFI, a PLC/Microprocessor based multi-function protection relay, referred to as IPR shall interface with the control, indication, and metering hardwire circuits, and with remote signals from the DC house control, monitoring, and display C02 panel. Signals between the IPR and the C02 shall be transmitted over fiber optic communication cables through an Ethernet switch and PLC IOMs as indicated in the Contract Drawings and Specifications. The IPR shall process data to provide appropriate outputs for the hard wire controls, and for the PLC display and controls with the following functions.

1. Phase Instantaneous and Time Overcurrent Functions (250/251): Relay shall be set to operate for faults on the incoming line cables and equipment.

2. Ground Instantaneous and Time Overcurrent Functions (250N/251N): Relay shall be set to operate for ground faults on the incoming line cables and equipment. Relay shall operate on the calculated residual or an independent ground current input for detection of ground faults.

    a. Phase and ground overcurrent relays devices 250/251 and 250N/251N shall trip vacuum fault interrupter directly, and shall enable the 286 lockout relay, as indicated. Device 286 lockout relay failure shall provide both local and remote annunciations.

3. Phase imbalance or negative sequence protection (Device 246), intended to provide protection against a loss of phase in the incoming 34.5 kV feeder or rectifier transformer.

4. Phase under/overvoltage (Device 227/259), relay shall include phase undervoltage and phase overvoltage functions for detecting single voltage event.

B. Sensing and Control:

1. The IPR shall have minimum of four optically isolated inputs, five general purpose output contacts, and one fail-safe normally closed alarm output contact. Each output shall be optically isolated and rated for tripping duty.

2. The IPR shall have front panel controls to open and close the vacuum fault interrupter. The controls shall allow setting of a time delay to allow to the operator, after activating a pushbutton, to move to an alternate location before the command is executed.

C. Security: The IPR shall have two user level groups as a minimum:

1. Basic Level: Allow access to:

   a. Time and date set function

   b. Alarm log displays

   c. Download stored data traces to laptop computer

   d. Download stored Alarm Log entries to laptop computer

2. Expert Level: Allow access to:

   a. All functions and their parameter settings

   b. Security passwords

3. A physical lock/key type security system is not acceptable.

D. Relay Logic. The relay shall include programmable logic for each output, input, and at least eight additional virtual outputs for user programming.

E. Selectable Wye or Delta Voltage Inputs. The relay shall be field selectable after installation to operate with either wye-connected (four-wire) or open-delta-connected (three-wire) potential transformers.

F. Terminal Blocks and Wiring. Connections, with the exception of the USB and Ethernet connections, or other communications wiring, shall be to barrier terminal strips capable of accepting ring lug connection. DIN style rail terminal blocks applied with wire pin terminal connectors may be used as an option.

G. Reporting and Alarms:

1. Data. The relay shall be capable of recording disturbances events up to 512 cycles (user adjustable lengths). The relay shall be capable of storing up to 2,048 cycles of data and events recorder. The relay shall be capable of automatically recording disturbance events of 15 to 40 cycles (user adjustable), with four cycles of prefault duration and user-defined triggering. The relay shall include sequence of events recording for the last 1,028 logic events minimum.

2. Oscillograph. The data shall be capable of display in graphical (oscilloscope) format on test equipment connected to the relay or downloaded to a remote location.

3. Nonvolatile Memory Status and Trip Target LEDs. The relay shall retain recent target, alarm, oscillography, and sequence of events recording information in nonvolatile memory.

4. Nonvolatile Status and Trip Target LEDs. The relay shall capture recent target and alarm information in nonvolatile memory. Information shall be provided locally through the user interface/LEDs at the C02 display panel and remotely via communication ports. The relay shall have three programmable alarm bits: major, minor, and logic, based upon relay logic states.

5. Circuit Breaker Monitor. The relay shall include breaker status and operations counter reporting, fault current interruption duty monitoring, and trip-speed monitoring. A trip coil monitor circuit shall be internally connected across the trip output to provide trip circuit continuity monitoring.

6. Multi-line display panel, capable of showing continuously monitored phase currents and single phase voltage, and alarms.

H. Communications Interface:

1. Relay Interface: The relay shall include three independent general-purpose communication ports. The function for each port is defined as follows:

    a. USB or serial port shall be provided to allow programming of the relay and retrieve data. The port shall be capable of the following functions:

        1) Receive trip indications.

        2) View relay settings, alarm history, and recorded current and voltage data.

        3) Revise user-adjustable relay settings.

        4) View system diagnostics indicating source of any relay malfunction.

        5) View system status indications.

        6) Download, install, remove, and re-configure relay operational software.

b. Controls and indications port shall interface with the control, monitor, and display C02 panel as indicated in Contract Specifications Section 34 21 33, Traction Power Control, Monitoring, and Display Panel. The port shall provide the following input/output functions:

1) VFI OPEN command.

2) VFI CLOSE command.

3) VFI OPEN indication.

4) VFI CLOSE indication.

5) VFI overcurrent trip.

6) View relay settings, alarm history, and recorded current and voltage data.

7) Analog data output: Instantaneous 34.5 kV AC voltages and currents.

c. Maintenance Ethernet Port. The Ethernet port shall be Internet Protocol (IP) addressable, capable of remote access through a non-routable implemented IP address schema from maintenance workstations. The maintenance port shall be capable of providing remote programming and retrieval of stored relay settings, alarms, diagnostics, current, and voltages.

I. Setting and Analysis Software:

1. Software shall be freely reproducible within the end user's organization without additional charge. The software shall include serial communications for settings upload and download; graphical programming and display of logic equations (including pictorial display of AND, OR and exclusive XOR gates); and ability to display and print oscillography and event files.

2. A laptop with software shall be provided as indicated in Contract Specifications Section 34 21 11, Multi-Function Protection Relay Equipment.

J. Other Relay Requirements

1. Control power: 125 V DC.

2. Memory: Non-volatile.

3. Noise rejection: meet requirements of IEEE C37.90.1, Surge Withstand Capability (SWC) Tests.

4. The IPR shall be capable of accepting a synchronization signal from the SCADA system so that clocks of the protective relays are synchronized to the same time.

K. Local Operator Interface

1. The local operator interface shall include:

a. An LCD display with a minimum of four lines and 16 characters per line. The LCD display shall be backlit so as to be legible in the dark.

b. A numeric or arrow keypad featuring pull-down menus allowing the user to:

1) View relay settings.

2) View alarm and measurement memories.

3) Change user-adjustable relay settings and parameters.

4) View system diagnostics.

2.04 125 VOLT DC CONTROL POWER

A. Control power for vacuum fault interrupter closing and tripping functions, and for energizing control, indication, monitoring and protective devices shall be from the 125 V DC control power as specified in Section 34 21 40, DC Control Power System.

B. A dedicated NEMA 3R enclosure box with terminal strip suitable for a two-conductor AWG No. 6 or larger, 125-volt DC control circuit shall be provided. Molded-case, thermal magnetic circuit breakers shall be provided for protection and isolation of each control circuit.

C. Control power voltage-monitoring relay shall be furnished and connected on the line side of the molded-case circuit breakers. Loss of control power shall be monitored locally and remotely.

D. Control power for the protection relay and VFI controls shall be provided by separate circuits.

E. Loss of protection relay control power shall cause tripping of the VFI.

2.05 120 VOLT AC POWER

A. A 120 V AC, 60 Hz, No. 2 AWG or larger 2-wire bus shall be provided for devices such as heaters, fans, lights, and receptacles.

2.06 INSTRUMENT TRANSFORMERS

A. Instrument transformers shall conform to IEEE C57.13 and NEMA C12.11. The current and potential transformers shall comply with the ANSI/IEEE relays and metering accuracy standards, and shall have 0.6 accuracy class or better, under the burdens imposed by the connected services.

B. Instrument transformers shall be insulated for 38 kV voltage class, and shall have basic impulse insulation (BIL) level of 200 kV full-wave.

C. Current Transformers

The current transformers (CTs) shall be dry type, of molded rubber or epoxy construction, multi-ratio, bushing, toroidal or wound-type:

1. Ratio and phase-angle characteristics of current transformers shall be suitable for the relaying or metering, as indicated.

2. CTs shall be installed in a manner such that they are easily accessible for inspection and maintenance.

3. Each VFI bushing shall be provided with one current transformer per phase rated 600/5A.

4. CTs and their secondary wiring shall be protected from induced voltages by metallic shielding. Secondary wiring shall utilize No. 10 AWG copper wire, and shall be run to readily identifiable terminal blocks in the VFI control compartment. The terminal blocks for the CTs shall be suitable for ring type wire connections, shall have covers, and shall feature integral shorting bars for the CT leads.

5. CTs shall be capable of withstanding thermal, magnetic, and mechanical stresses from the flow of current equal to the interrupting and momentary routings of the circuit breakers.

D. Potential Transformer

Potential transformer (PT) shall be of the molded rubber or epoxy-encapsulated construction, with primary current-limiting fuses as indicated:

1. Primary and secondary circuits of PT shall be protected by means of non-renewable cartridge type fuses. Seconday circuit fuses shall be installed in the low voltage circuits of the PT. Blown fuse shall be indicated locally and remotely.

2. PT shall have voltage ratio of 34,500 V primary to 115 V secondary, and shall be connected between phase A and phase B.

2.07 TERMINATIONS

A. The incoming line section of the VFI shall accommodate 3-# 2/0 AWG, 35 kV power cable entering from below. At least 24 inches below the switchgear floor shall be provided for terminating the cable as indicated.

B. The load side section of the VFI shall accommodate 3-# 2/0 AWG, 35 kV cable entering from above originating from the primary side of the rectifier transformer as indicated.

C. 35 kV power cable terminations shall be as specified in Section 34 21 23, Traction Power Cables. NEMA 2-hole cable connections shall be provided.

D. Low voltage terminations shall be as specified in Section 34 21 50, Common Materials and Methods for Traction Power.

2.08 SEPARABLE INSULATED CONNECTORS

A. The separable insulated connectors shall be elbow type connectors, made of vacuum cast resin, submersible, rated at 35 kV, 600A rms continuous, 1 kA rms for 24 hour overload, 25 kA rms symmetrical for 0.17 second, and 10 kA symmetrical for 3 seconds, deadbreak type, with test points and operating eye. Provide ground provisions rated 10 kA symmetrical, or per system coordination study.

B. Refer to Section 34 21 19, Separable Insulated Connectors for requirements related to:

1. Article 2.01.B.2 regarding material construction, vendors and standard compliance.

2. Article 2.01.B.4 regarding traction power cable type.

3. Article 2.01.B.2 regarding shielding and grounding.

2.09 FACTORY TESTING

A. General: Testing of the VFI shall be in accordance with the requirements of Contract Specification Section 01 45 24, Testing Program Requirements.

B. Design Tests: The following design tests shall be performed on one VFI. The testing shall be performed by a company or agency certified by the International Electric Testing Association (IETA):

1. For the AC vacuum fault interrupter switchgear, perform design test or submit certified design test data for the following:

   a. Switch ratings in accordance with IEEE C37.74.

   b. Interrupter ratings in accordance with IEEE C37.60.

   c. Construction and cubicle coatings in accordance with IEEE C57.12.29.

2. For the integrated protection relay, perform design test or submit certified design test data for the following:

   a. Dielectric Strength: Tests per IEEE 37.90 and for the instrument transformer inputs at voltages as required.

   b. Surge Withstand Capability (SWC): Tests involving oscillatory and fast transient surges per IEEE 37.90.1.

   c. Performance Verification Tests: These tests shall be developed in adequate detail by the Supplier and the testing agency, and shall be used to ascertain the proper functioning, accuracy, and response time of the IPR. At a minimum, design tests shall include the following:

      1) Input voltage measurements (accuracy and range verification).

      2) Input current measurements (accuracy and range verification).

3) Verification of the proper operation of protective functions.

4) Verification of the proper functioning of the self-diagnostic features, including trouble alarms, events storage, and current and voltage data traces.

5) Verification of the proper operation of user interfaces, including parameter updates through the operator interface panel and interrogation/diagnostics via the communications ports.

6) Verification of the correct operation of the IPR when the control power supply voltage is varied within the specified operating range.

7) Verification of the proper functioning of IPR inputs and outputs.

8) Verification of proper communications between the IPR communications module and the C02 panel as indicated in Contract Specifications Section 34 21 33, Traction Power Control, Monitoring, and Display Panel. The Supplier shall supply a PLC to the IPR manufacturer for test purposes.

C. Production Tests:

1. Switchgear factory tests shall consist of the following production tests:

   a. Continuity test.

      1) Perform continuity checks to verify current transformer connections, shunt leads, and medium voltage fuses.

   b. Hi-pot test.

      1) Perform dielectric withstand (high-potential) test at 50 kV for one minute on each phase with the VFI closed and the poles not under test grounded.

      2) For each test, record date, time, temperature, humidity, voltage levels, leakage current, and megaohm values.

   c. Pressure test to assure tank is completely sealed.

   d. Electrical functional testing with remote control and indication.

   e. PT and CT ratio tests.

2. IPR factory tests shall consist of the following production tests:

   a. Confirmation of the correct calibration for current and voltage measurements of the isolation transducer, and proper functioning of the IPR software.

   b. Confirmation of the correct values for all default settings.

   c. Confirmation of the proper operation of user interfaces including operator interface, RS-232, and Ethernet user interfaces.

   d. Confirmation of the proper operation of protective functions, by the use of simulated fault conditions.

   e. Confirmation of the proper functioning of inputs and outputs of the IPR, by use of secondary voltage and current injection.

D. Instrument Transformers:

1. Instrument transformers shall be factory tested in accordance with IEEE C57.13.

PART 3 – EXECUTION

3.01 TRACTION POWER SYSTEM FIELD ACCEPTANCE TESTING

A. Refer to Section 34 21 80, Traction Power System Field Acceptance Testing, for requirements.

B. Provide recommended field test procedures.

END OF SECTION 34 21 16

SECTION 34 21 17

AC SWITCHGEAR, SF-6 GAS INSULATED TYPE

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. General

B. Operating requirements

C. Ratings

D. Switchgear enclosure

E. Circuit breakers

F. Three position switches

G. Buses and bus connections

H. Grounding

I. 125 Volt DC control power

J. 120 Volt AC power

K. Terminations

L. Equipment protection

M. Instrument transformers

N. Appurtenances and auxiliary devices

O. Maintenance accessories

P. Factory testing

Q. Field acceptance testing

1.02 RELATED SECTIONS

A. Section 01 33 00 Submittal Procedures

B. Section 01 33 23 Shop Drawings, Product Data, and Samples

C. Section 01 42 00 Quality Assurance

D. Section 01 45 00 Quality Control

E. Section 01 45 24 Testing Program Requirements

F. Section 01 78 23 Operation and Maintenance Data

G. Section 01 78 44 Spare Parts and Maintenance Manuals

H. Section 34 21 05 Prefabricated AC and DC Equipment Houses

I. Section 34 21 40 DC Control Power System

J. Section 34 22 23 Traction Power Cables

K. Section 34 21 50 Common Materials and Methods for Traction Power

L. Section 34 21 80 Traction Power System Field Acceptance Testing

1.03 MEASUREMENT AND PAYMENT

A. Measurement: AC switchgear will be measured for payment for each unit that is tested and furnished in accordance with the Contract Drawings and Contract Specifications.

B. Payment: AC switchgear will be paid for at the Contract unit price for each unit as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. American National Standards Institute (ANSI):

1. ANSI C37.54 Indoor Alternating Current High-Voltage Circuit Breakers Applied as Removable Elements in Metal Enclosed Switchgear – Conformance Test Procedures

2. ANSI C37.57 Switchgear – Metal Enclosed Interrupter Switchgear Assemblies – Conformance Testing

3. ANSI C37.58 Switchgear – Indoor AC Medium-Voltage Switches for Use in Metal-Enclosed Switchgear – Conformance Test Procedures

B. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE C37.010 Application Guide for AC High-Voltage Circuit Breakers > 1000 Vac Rated on a Symmetrical Current Basis

2. IEEE C37.04 Standard Rating Structure for AC High-Voltage Circuit Breakers

3. IEEE C37.06 Standard for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis – Preferred Ratings and Related Required Capabilities for Voltages Above 1000 V

4. IEEE C37.09 Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on Symmetrical Current Basis

5. IEEE C37.016 Standard for AC High Voltage Circuit Switchers Rated 15.5 kV through 245 kV

6. IEEE C37.20.3 Standard for Metal Enclosed Interrupter Switchgear (1 kV – 38 kV)

7. IEEE C37.20.7 Guide for Testing Switchgear Rated Up to 52kV for Internal Acing Faults

8. IEEE C37.122.2 Guide for the Application of Gas-Insulated Substations 1 kV to 52 kV.

9. IEEE C57.13 Standard Requirements for Instruments Transformers

C. National Electrical Code (NEC):

1. NFPA 70 National Electrical Code

D. National Electrical Manufacturer's Association (NEMA):

1. NEMA EL 21.2 Instrument Transformers for Revenue Metering (125 kV BIL Through 350 kV BIL)

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures; and Section 01 33 23, Shop Drawings, Product Data, and Samples for submittal requirements and procedures.

B. Product Data: Submit product data for components specified herein.

C. Design Drawings: Provide design drawings for the 34.5 kV gas insulated switchgear and associated devices, including equipment layouts, and circuit breaker control schematics.

D. Protective relay settings and communications interfaces with C02 panel PLC.

E. Test plan and procedures for factory testing.

F. Test report for factory testing.

G. Operation and Maintenance Manuals: Provide the following operation and maintenance manuals in accordance with Section 01 78 23, Operation and Maintenance Data.

1.06 QUALITY ASSURANCE AND SUPPLIER QUALIFICATIONS

A. Electrical components, devices, and accessories shall be listed and labeled in conformance with NFPA 70, Article 100. Electrical components, devices, and accessories and their installation shall comply with NECA's National Electrical Installation Standards (NEIS).

B. The manufacturer of the 34.5 kV AC switchgear and 34.5 kV circuit breakers shall have a minimum of five years of successful and proven transit, industrial or utility experience in providing equipment like the one specified herein.

C. The manufacturer of the AC switchgear's auxiliary equipment, devices and components shall have a minimum of five years of successful and proven design and manufacturing experience in such products, providing they are equivalent to the one specified herein.

1.07 DELIVERY, STORAGE AND HANDLING

A. Equipment shall be weatherproofed for shipment. Connection openings shall be closed to prevent entrance of foreign material during shipment and storage.

B. Equipment shall be handled and stored in conformance with manufacturer's instructions. One copy of these instructions shall be included with the equipment at time of shipment.

1.08 SPARE PARTS, TEST EQUIPMENT, AND TOOLS

A. Mandatory Spare Parts: Furnish the following mandatory spare parts required to maintain and operate the 34.5 kV gas insulated switchgear in accordance with the requirements of Section 01 78 44, Spare Parts and Maintenance Materials.

1. Blocking coil ground or isolator switch: 2 each
2. Motor for ground or isolator switch: 2 each
3. Isolator or grounding switch auxiliary contacts: 2 each
4. Motor for spring charging of circuit breaker: 2 each
5. Varistor for circuit breaker motor: 2 each
6. Circuit breaker trip or close coil: 4 each
7. Circuit breaker control power under voltage trip coil: 1 each
8. Camera for isolator/ground Switch: 1 each
9. Circuit breaker auxiliary contacts: 1 each
10. Spring charging auxiliary contacts: 1 each

11. Intelligent Voltage Information System (IVIS-F) Display: 1 each

12. Intelligent Displays (IDIS): 1 each

13. Density switch for IDIS (with cable): 1 each

14. Dummy section for easy, quick and safe return to service after circuit breaker failure: 1 each

15. Lubrication kit (including cleaning agent, grease and lubricant): 1 each

B. Recommended Spare Parts: Provide a recommended list of spare parts, tools, and test equipment in accordance with the requirements of Section 01 78 44, Spare Parts and Maintenance Materials.

1.09 MAINTENANCE ACCESSORIES

A. Provide necessary equipment and accessories recommended by the equipment Supplier needed for the normal operation and preventive maintenance of the AC switchgear.

PART 2 – PRODUCTS

2.01 GENERAL

A. The functions of the 34.5 kV gas insulated switchgear assembly in each traction power facility are as described below.

1. In switching stations, the 34.5 kV switchgear receives three-phase, 60 Hz, 34.5 kV power from the high-voltage 115/34.5 kV substation and distributes it by means of two 34.5 kV sub-transmission feeders to the traction power substations installed along the tracks, as indicated. In certain switching station locations, the AC switchgear is provided with an additional circuit breaker, which supplies power to auxiliary substations feeding the subway ventilation system.

2. In traction power substations (TPSS), the 34.5 kV switchgear receives power from the two sub-transmission feeders and distributes it to two transformer/rectifier units via a sectionalized bus. Each 34.5 kV feeder is terminated on the line side of a 34.5 kV feeder circuit breaker, whose load side is connected to a rectifier transformer. A normally open bus-tie circuit breaker is provided, also connected between the load sides of the two feeder circuit breakers. The two 34.5 kV feeder circuit breakers are normally closed.

3. In sectionalizing stations, the AC switchgear divides the 34.5 kV sub-transmission system between adjacent high-voltage substations into line sections and provides the capability to connect the two adjoining line sections during outage of either high-voltage substation.

B. The AC switchgear shall be housed in an outdoor, walk-in type, transportable prefabricated house, as specified in Section 34 21 05, Prefabricated AC and DC Equipment Houses. The 34.5 kV gas insulated switchgear shall include SF-6 insulated, type tested, single phase, metal enclosed vacuum interrupters, and shall include three-position disconnector and grounding switches, power cable terminations, instrument transformers, indicating devices, protective and auxiliary relays, terminal blocks, control circuitry, interlocks, switches, and all other equipment, panels, and devices as indicated for a complete operating installation.

2.02 OPERATING REQUIREMENTS

A. The 34.5 kV circuit breakers shall be provided with both local and remote control and monitoring. Each 34.5 kV circuit breaker shall be provided with disconnector and grounding switches.

B. At the switching stations, the 34.5 kV circuit breakers shall be normally closed to keep both sub-transmission feeders energized under normal operating conditions.

C. At the sectionalizing stations, the 34.5 kV circuit breakers shall be normally open.

D. At each TPSS, operation of the circuit breakers shall be as follows:

1. Under normal operating condition, the two 34.5 kV feeder circuit breakers shall be closed, and the 34.5 kV bus tie circuit breaker shall be open. The line side of each feeder circuit breaker shall be connected to the incoming 34.5 kV sub-transmission feeder and the load side connected to the rectifier transformer.

2. The two 34.5 kV feeder circuit breakers and the bus tie circuit breaker shall be equipped with an automatic transfer scheme (ATS) such that upon loss of power on one of the incoming 34.5 kV sub-transmission feeder, after a short time delay, it will automatically trip the affected 34.5 kV feeder circuit breaker and automatically close the normally open 34.5 kV tie circuit breaker. Similarly, upon loss of power on the other incoming 34.5 kV sub-transmission feeder, the corresponding normally closed feeder circuit breaker will automatically trip after a short time delay and then close the normally open 34.5 kV tie circuit breaker. No paralleling of the two 34.5 kV feeder circuit breakers will be allowed and no automatic transfer will be permitted if there are any system faults (i.e., phase to phase or phase to ground or phase current unbalanced).

3. During manual operation, the 34.5 kV feeder and bus tie circuit breakers shall have the capability to operate with one feeder circuit breaker closed and the bus tie circuit breaker closed. Controls shall be designed to allow only two out of three circuit breakers to be closed at any one time.

4. The circuit breakers and the three-position disconnector and grounding switches are electro-mechanically interlocked to only operate with the circuit breaker in the open position. The three-position switch shall be prevented from switching through the CLOSED state in the “ready to earth” state. Closing of the circuit breaker shall be blocked if the three-position switch is in an intermediate position.

5. The 34.5 kV circuit breaker and three-position switch operation and interlocking shall function as specified in IEEE C37.122.2.

6. Outdoor type 34.5 kV elbow disconnectors or visible disconnect switches in an isolation disconnect switch (IDS) function as switching devices between the primary side 34.5 kV sub-transmission system cables and the 34.5 kV AC switchgear circuit breaker. The 34.5 kV circuit breaker is equipped with disconnector/grounding switches on the line and load sides of the circuit breaker. The corresponding 34.5 kV disconnector/grounding switches shall be interlocked with the 34.5 kV visible disconnect switch so that the disconnector/grounding switches can only be operated when the visible disconnect switch is opened and no voltage is present on the 34.5 kV feeder circuit. This ensures ground is never applied to an energized cable.

2.03 RATINGS

A. The 34.5 kV gas insulated switchgear ratings shall be in accordance with IEEE C37.06, IEEE C37.20.3, and IEEE C37.016, and shall be as follows:

1. Nominal Voltage, Line-to-Line: 34.5 kV, rms

2. Rated Max Voltage: 38 kV, rms

3. Rated Low Frequency Withstand: 80 kV, rms

4. Rated Full Wave Impulse Withstand: 150 kV, rms

5. Rated Frequency: 60 Hz

6. Rated Continuous Current: 1200A, rms

B. The 34.5 kV Vacuum circuit breakers shall be rated in accordance with IEEE C37.06 and IEEE C37.016 and shall have the following minimum ratings:

1. Rated Short-Circuit Withstand Current: 25 kA, rms

2. Rated Peak Withstand Current: 65 kA

3. Breaker Rated Interrupting Time: 3 cycles

4. Rated Short Circuit Making Current (max.): 65 kA, rms

5. Rated Short Circuit Breaking Current: 25 kA, rms

2.04 SWITCHGEAR ENCLOSURE

A. Switchgear assemblies for vacuum circuit breakers, bus bars, disconnector and grounding switches, and associated instrument transformers and devices shall be of the metal enclosed type, Sulfur hexafluoride (SF-6) insulated and shall form a line-up of dead front, freestanding cubicles. Each cubicle shall consist of three single pole vacuum circuit breakers, bus bars, disconnector and grounding switches, relays, devices and incoming cable entering from above or below as indicated in the Contract Drawings. The circuit breaker and bus bars housings shall be separated from each other with gas tight bushings.

B. Cubicle housing shall consist of a corrosion resistant, a high nickel content aluminum alloy material assembled using O-rings for gas tightness, or a stainless steel or galvanized steel welded, or bolted, structure enclosing all sides and top except openings for specific purposes. The structure shall support equipment under normal and short-circuit conditions.

C. In case of an arc fault, each closed gas compartment shall have its own pressure relief valve, preventing rupture of the housing. The gas compartment shall be equipped with gas monitoring device complete with auxiliary contacts for local and remote alarm indications. Settings for the gas monitoring device shall be provided by the equipment Supplier to the District.

D. Each cubicle control panel and low voltage cabinet shall have front hinged doors. At a minimum, the doors shall meet the following requirements:

1. The doors shall support flush and semi-flush mounted devices and not distort from a plane surface in any position. The doors shall be supported by concealed hinges.

2. Each front hinged door shall have a handle and a mechanical three-point vibration proof latch for holding it in a closed position.

3. Each front door shall be provided with a stop to hold the door in the open position, so that door-mounted devices will not touch other devices mounted on adjacent doors.

4. The front doors shall have provisions for padlocking.

E. Top cable entrance shall be provided for external power and control terminations as indicated on the Contract Drawings. Ample space shall be provided for cable pulling, cable termination, and performing high potential tests on cables without having to remove the terminations from the cubicle.

F. Switchgear assembly items requiring inspection, operation or maintenance shall be installed not higher than 72 inches off the floor and shall be accessible from the front.

2.05 CIRCUIT BREAKERS

A. General

1. The circuit breakers shall be sealed vacuum type and shall be rated in accordance with IEEE C37.04 and IEEE C37.06. Circuit breaker design shall incorporate the following features:

    a. The circuit breakers shall be three single pole stored-energy operating mechanism type, rated for service on a three-phase, effectively grounded-neutral, 60 Hz system at a nominal operating voltage of 34.5 kV line-to-line.

    b. The circuit breaker control circuits and stored-energy mechanism charging motor shall operate from a 125 V DC source.

    c. The circuit breakers shall successfully close over a voltage range from 90 V DC to 140 V DC, and trip over a voltage range from 75 V DC to 140 V DC.

2. Circuit breakers shall be designed to interrupt the rated short-circuit current in a sealed vacuum with a separate vacuum chamber for each phase of the circuit breaker.

    a. Contact erosion indication shall be provided on each interrupter pole assembly, for evaluation of wear on the main contacts over the life of the circuit breaker.

    b. Circuit breakers shall only have one internal movable contact per phase in the vacuum interrupter.

B. Operating Mechanism

1. The circuit breaker shall be operated by a stored-energy mechanism, and shall be motor-charged, spring type, mechanically and electrically trip-free, and non-pumping. Circuit breaker design shall include provisions for manual charging of the stored-energy mechanism. The use of hydraulic or pneumatic operating mechanisms is not acceptable.

2. A SPRING CHARGE indicator shall be provided on the front of the control panel showing the status of the closing spring. A white indicating LED shall be provided on the front door to indicate when the closing spring is fully charged.

3. The closing spring shall be re-charged automatically once the circuit breaker has been closed.

C. Circuit Breaker Controls

1. A control switch shall be provided on the front door of the control panel of each breaker unit for electrical tripping of the breaker only.

2. A LOCAL-REMOTE selector switch (local cubicle) shall be provided on the front door of each breaker unit for electrical closing of the breaker in the connected position. When using this function, the close shall be actuated with a programmable time delay.

3. Manual local control of the breaker shall be provided when the AC breaker is in the CONNECTED position, when the control switch on the control and annunciator panel (C02) PLC or C04 Ethernet switch is inoperable, and when the LOCAL-REMOTE selector switch is in the LOCAL position. An input/output module (IOM) shall be installed in the C02 panel and its matching pair installed with the AC switchgear lineup. IOMs can be directly wired to more than one AC circuit breaker IPR.

4. Each circuit breaker shall be provided with a manually-operated mechanical means for tripping the circuit breaker. Open and close mechanical position indications shall be provided on the front control panel. The mechanical grounding lever shall be lockable and taggable for a grounded feeder circuit.

5. Circuit breakers shall be designed for remote control operation as specified in Section 34 21 33, Control, Monitoring and Display Panel. Remote commands shall be able to trip the breaker at all times while in the connected position but shall be able to close it only when both the LOCAL-REMOTE selector switch located at C02 panel and the LOCAL-REMOTE selector switch on the front of each circuit breaker unit are in the REMOTE position.

6. Controls for the circuit breakers shall be interlocked with the rectifier doors in the traction power substation, such that any door opening shall trip the main and tie circuit breakers connected to their respective transformer/rectifier unit. If one unit is out-of-service, the protective relay logic and interlocking shall permit operation of the substation with one transformer-rectifier unit only.

7. Provide remote SCADA indications to the OCC for the open/close status and CONNECTED position of each circuit breaker.

8. Auxiliary contacts shall be operated by the breaker mechanism in both the TRIPPING and CLOSING operations.

9. Auxiliary contacts including spares shall be wired to the terminal blocks and properly labeled.

10. Four-digit operation counter shall be provided to record tripping operations.

D. Circuit Breaker Status Indications

1. The open and closed status of the breakers shall be indicated, respectively, by green and red LEDs mounted on the control panels and by mechanical flag indicators.

    a. The red BREAKER CLOSED indicating LED and auxiliary relay for remote indication shall be connected to monitor the continuity of the trip circuit.

b. The indicating LEDs and the mechanical flags shall be visible when the circuit breaker compartment door is closed.

2. A flag indicator, visible when the door is closed, shall be provided to indicate the position of the circuit breaker.

3. Dry auxiliary contacts wired to terminal blocks shall be provided for remote breaker status and position indications.

2.06 THREE POSITION SWITCHES

A. The disconnector and grounding switches rated at 1200A, shall be designed as single three-position switches. In combination with the circuit breaker, the no load break three-position switch shall enable feeder grounding through the closed circuit breaker.

B. The three-position switches' stationary and movable contacts shall be mounted in the bus bar housing with mechanical coupling made through an external shaft.

C. The three-position switch operating mechanism shall be located on the front control panel with two operating functions (disconnecting and grounding). Separate interlocked operating handles shall be provided.

D. The switching positions of the three-position switches shall be visually monitored using a web-camera system and shall be displayed with a provided laptop computer. Alternatively, provide a visual monitoring capability.

E. A mechanical switch position indication for connected and grounding switch positions shall be provided.

F. To prevent the three-position switch from operating under load, the three-position switch shall be electro-mechanically interlocked to only operate with the circuit breaker in the open position as indicated on the Contract Drawings. The three-position switch can only be brought into the ready-to-earth position if the disconnector and circuit breaker are open. The three-position switch shall be prevented from switching through from the CLOSED state into the ready-to-earth state. Closing of the circuit breaker shall be blocked if the three-position switch is in an intermediate position.

G. If the control voltage fails, an interlocked emergency operation of the feeder shall be possible.

H. For the disconnector switch, a minimum of ten auxiliary contacts (4 NO + 4 NC + 2 CO) shall be provided for local and remote position indications.

I. For the grounding switch, a minimum of eight auxiliary contacts (2 NO + 2 NC + 4 CO) shall be provided for local and remote position indications.

2.07 BUSES AND BUS CONNECTIONS

A. The 34.5 kV single pole buses shall be made of insulated copper bars and shall be of sufficient size to carry the continuous rated current, without exceeding the temperature limit of 40 degrees Celsius. The continuous rating of bus and bus connections shall be 1200 amperes.

B. The phasing of the power provided is counterclockwise, such that the A is 0 degrees, B is 240 degrees, and C is 120 degrees. The phase sequence of three-phase assembled buses and primary conductors shall be A-B-C counting from front to back, top to bottom, or left to right as viewed from the front side of the switchgear assembly.

C. The buses shall be supported and braced between each other and to the enclosure with high strength anti-hygroscopic, flame-retardant, non-tracking insulators, so that the buses withstand the thermal and mechanical stresses due to maximum short-circuit currents equal to the maximum symmetrical withstand and 3-second short time current ratings of the circuit breaker protecting the bus.

D. Bus bars including runbacks shall be insulated with track-resistant, flame-retardant epoxy coating. Bus joints shall be insulated with flexible or molded removable resin boots.

E. Bus joints and connections shall be of the bolted construction. They shall:

1. Be acid etched and plated with electro-deposited silver after buses have been bent or formed. Bending after the plating process will not be allowed.

2. Be made with Belleville-type washers and high-strength, rust resistant steel bolts, such as cadmium-plated or galvanized. Bolt shall be capable of being properly torqued and locked in place.

F. Bus joints shall have conductivity at least equal to that of the bus bars, and each joint shall be so clamped such that no loss of conductivity will occur during the life of the equipment.

G. Access plates shall permit assembling joints and inspecting bolted connections after installation of the bus enclosure.

2.08 GROUNDING

A. A copper ground bus with a symmetrical withstand current rating equal to that of the circuit breaker shall extend throughout the entire length of the switchgear assembly. Ground bus shall not be less than 1/4-inch by 2 inches in size.

B. At least two 9/16-inch diameter holes at 1-3/4-inch centers shall be provided at each end of the bus.

C. Provide grounding knobs on the ground bus and on each phase bus for safety grounding of the incoming 34.5 kV cables and phase buses. The grounding knobs shall be provided with removable insulated caps for the grounding device.

D. Each cubicle shall be grounded directly to the ground bus. Cubicle doors and panels shall be provided with a flexible copper braid ground strap attached to the structure framing.

E. Grounding connections shall be metal-to-metal, with any nonconductive coatings such as paint or lacquers removed to ensure solid electrical contact.

F. The ground bus shall have provisions for connecting ground cables in each cubicle and at the ends of the switchgear lineup.

2.09 125 VOLT DC CONTROL POWER

A. Control power for circuit breaker closing and tripping functions, and for energizing control, indication, monitoring, and protective devices shall be from the 125 V DC control power as specified in Section 34 21 40, DC Control Power System.

B. A two-conductor AWG No. 6 or larger, 125 V DC control bus with a minimum 600 V insulation shall be provided for the full length of each switchgear assembly.

C. The control bus shall:

1. Run in a protective raceway;

2. Be terminated on a terminal block for connection to the power supply source; and

3. Be tapped at each cubicle served and extended to the associated circuit breaker control compartment.

D. Molded-case, thermal magnetic circuit breakers shall be provided for protection and isolation of each control circuit in each switchgear cubicle.

E. Control power voltage-monitoring relay shall be furnished and connected on the load side of the molded-case circuit breaker in each switchgear cubicle.

2.10 120 VOLT AC POWER

A. A 120 V AC, 60 Hz, No. 2 AWG or larger 2-wire bus shall be provided for devices such as heaters, fans, lights, and receptacles.

B. The AC bus shall:

1. Extend for the full length of each switchgear assembly;

2. Be terminated on a terminal block for connection to an external power supply; and

3. Be tapped in each switchgear cubicle for connections of space heaters, fans, lights, and receptacles. Lighting circuits shall be independent from other circuits.

2.11 TERMINATION

A. Unless otherwise indicated, power cables shall enter and leave the switchgear at the bottom. Provisions shall be made to accommodate the number of cables indicated.

B. The bus connections for the 34.5 kV single-conductor power cables shall be coordinated with the size of the cable terminations and shall not be located lower than 24 inches above the switchgear floor if the power cables are entering from below.

C. 34.5 kV power cable terminations shall be as specified in Section 34 22 23, Traction Power Cables. NEMA 2-hole cable connections shall be provided for the cable size indicated.

D. Low voltage terminations shall be as specified in Section 34 21 50, Common Materials and Methods for Traction Power.

E. A capacitive voltage detecting system or a low resistance modified (LRM) with a plug-in indicator voltage detecting system for each 34.5 kV feeder cable shall be provided.

2.12 EQUIPMENT PROTECTION

A. Relaying, metering, and indicating devices shall be provided as shown on the Contract Drawings, and as specified herein. Refer to Section 34 21 50, Common Materials and Methods for Traction Power, for general requirements of protective relays and indicating devices.

B. Provide control and indication functions in accordance with Contract Specifications Section 34 21 33, Traction Power Control, Monitoring, and Display Panel and Related Equipment.

C. Equip each 34.5 kV feeder circuit breaker and bus tie circuit breaker with a microprocessor-based multi-function protection relay, referred to as integrated protection relay (IPR) as specified in Specifications Section 34 21 12, Integrated Protection Relay Equipment.

D. At traction power facilities using 34.5 kV switchgear, IPR shall be used for protection and for circuit breaker control. Apply protection functions as indicated on the Contract Drawings.

E. Backup Control Systems

1. Provide backup controls described in item 2.05.C.3 in addition to the primary control and protection devices. If a phase or ground fault occurs on a 34.5 kV transformer-rectifier circuit, the corresponding 34.5 kV feeder circuit breaker and 34.5 kV bus tie circuit breaker shall be tripped directly by its primary or back-up protection devices, or through its corresponding lockout relay, device 286, as indicated on the Contract Drawings.

2. If there is any failure in the fiber optic cable associated with the protection relay, the feeder circuit breakers, 252-1 and 252-2, and bus tie circuit breaker, 252-8, shall be tripped through its back-up remote IOM.

F. Control and Communication Functions

1. Coordinate the C02 panel to implement controls, indications, and data transfer between the IPR relays and the C02 panel for local and remote control, indication, and data transfer functions and processes. Communication between IPR relays and the C02 PLC shall use the DNP3 protocol.

2.13 INSTRUMENT TRANSFORMERS

A. Instrument transformers shall conform to IEEE C57.13 and NEMA EL 21.2. The current and potential transformers shall comply with the IEEE C57.13 relaying and metering accuracy standards, and shall have 0.6 accuracy class or better, under the burdens imposed by the connected services. This accuracy limit does not apply to revenue metering which is described in Article 2.13.C.6 and 2.13.D.5.

B. Instrument transformers shall be insulated for 38 kV voltage class and shall have basic impulse insulation (BIL) level of 200 kV full-wave.

C. Current Transformers

The current transformers (CTs) shall be dry type, of molded rubber or epoxy construction, multi-ratio, bushing, toroidal or wound-type:

1. Ratio and phase-angle characteristics of current transformers shall be suitable for the relaying or metering, as indicated.

2. CTs shall be installed in a manner such that they are easily accessible for inspection and maintenance.

3. In TPSSs and switching stations, each breaker cubicle shall be provided with two CTs per phase rated 1200/5A and the bus tie circuit breaker cubicle shall be provided with one current transformer per phase rated 1200/5A as indicated. In sectionalizing stations, each breaker cubicle shall be provided with one CT per phase as indicated.

4. CTs and their secondary wiring shall be protected from induced voltages by metallic shielding. Secondary wiring shall utilize No. 10 AWG copper wire and shall be run to readily identifiable terminal blocks in the low voltage control panel. The terminal blocks for the CTs shall be suitable for ring type wire connections, shall have covers, and shall feature integral shorting bars for the CT leads.

5. CTs shall be capable of withstanding thermal, magnetic and mechanical stresses from the flow of current equal to the interrupting and momentary current ratings of the circuit breakers.

6. CTs for revenue metering application shall be 0.15 percent across Burden Classes B1 thru B8 as defined by IEEE C57.13.6.

D. Potential Transformers

Potential transformers (PTs) shall be of the molded rubber or epoxy-encapsulated construction, with primary current-limiting fuses outside the primary enclosure as indicated:

1. PTs shall be mounted and connected on the line side of the three-position switch via plug-in cable and shall be easily accessible for inspection and maintenance.

2. Primary and secondary circuits of PTs shall be protected by means of non-renewable cartridge type fuses. Secondary circuit fuses shall be installed in the low voltage control panel and shall be located to permit replacement when the switchgear is in service.

3. PTs shall have voltage ratio of 20,125/115 V, and shall be connected between phase A and neutral, phase B and neutral, and phase C and neutral.

4. PTs for revenue metering application shall be 0.15 percent across Burden Classes W to ZZ as defined by IEEE C57.13.6.

2.14 APPURTENANCES AND AUXILIARY DEVICES

A. AC switchgear appurtenances and auxiliary devices, such as control switches, wiring devices, low voltage wires and cables, and indicating lights shall be as specified in Section 34 21 50, Common Materials and Methods for Traction Power.

2.15 FACTORY TESTING

A. General: Testing shall be performed in accordance with the requirements of Section 01 45 24, Testing Program Requirements.

B. Factory Tests:

1. The following design tests shall be performed on one AC switchgear assembly, complete with associated 34.5 kV AC circuit breakers:

   a. Applicable tests identified as design tests in IEEE C37.09 for the circuit breaker.

   b. Applicable tests identified as design tests in ANSI C37.54 and ANSI C37.58 for the switchgear assembly.

   c. Performance verification tests on switchgear control circuits including automatic transfer.

2. The following production tests shall be performed on AC switchgear assemblies, complete with their associated 34.5 kV AC circuit breakers:

   a. Applicable tests identified as Production Tests in IEEE C37.09 for the circuit breakers.

b. Applicable tests identified as Production Tests in ANSI C37.54, ANSI C37.57 and ANSI C37.58 for the switchgear assemblies.

c. Functional tests on switchgear control circuits including automatic transfer between the substation 34.5 kV feeder circuit breakers and bus tie circuit breaker.

PART 3 – EXECUTION

3.01 FIELD ACCEPTANCE TESTING

Refer to Section 34 21 80, Traction Power System Field Acceptance Testing for requirements.

END OF SECTION 34 21 17

SECTION 34 21 18

AC SWITCHGEAR, SEALED VACUUM TYPE

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. General

B. Operating requirements

C. Ratings

D. Switchgear enclosure

E. Circuit breakers

F. Buses and bus connections

G. Grounding

H. 125 Volt DC control power

I. 120 Volt AC power

J. Terminations

K. Equipment protection

L. Instrument transformers

M. Appurtenances and auxiliary devices

N. Maintenance accessories

O. Factory testing

P. Traction power facility system factory functional testing

Q. Field acceptance testing

1.02 RELATED SECTIONS

A. Refer to the following Sections for requirements:

1. Section 01 33 00 Submittal Procedures
2. Section 01 33 23 Shop Drawings, Product Data, and Samples
3. Section 01 45 24 Testing Program Requirements

4. Section 01 78 23 Operation and Maintenance Data
5. Section 01 78 44 Spare Parts and Maintenance Data
6. Section 34 21 05 Prefabricated AC and DC Equipment Houses
7. Section 34 21 33 Control, Monitoring and Display Panel
8. Section 34 21 40 DC Control Power System
9. Section 34 21 50 Common Materials and Methods for Traction Power
10. Section 34 21 75 Traction Power Facility System Factory Functional Testing
11. Section 34 21 80 Traction Power System Field Acceptance Testing
12. Section 34 22 23 Traction Power Cables

1.03 MEASUREMENT AND PAYMENT

A. Measurement: AC switchgear will be measured for payment for each unit that is tested and furnished in accordance with the Contract Specifications.

B. Payment: AC switchgear will be paid for at the Contract unit price for each unit as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM F855 Standard Specification for Temporary Protective Grounds to be used on De-energized Electric Power Lines and Equipment

B. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE C37.010 Application Guide for AC High Voltage Circuit Breakers > 1000 VAC Rated on a Symmetrical Current Basis
2. IEEE C37.04 Standard Rating Structure of AC High-Voltage Circuit Breakers
3. IEEE C37.06 Standard for AC High-Voltage Circuit Breakers Rated on Symmetrical Current Basis-Preferred Ratings and Related Required Capabilities for Voltages Above 1000V
4. IEEE C37.09 Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
5. IEEE C37.20.2 Standard for Metal-Clad Switchgear

6. IEEE C37.20.4 Standard for Indoor AC Switches (1 kV to 38 kV) for Use in Metal-Enclosed Switchgear

7. IEEE C57.13 Standard Requirements for Instrument Transformers

C. National Electrical Manufacturers Association (NEMA):

1. NEMA SG 4 Alternating Current High Voltage Circuit Breakers

2. NEMA/ANSI C37.51 For Switchgear – Metal-Enclosed Low-Voltage AC Power Circuit Breaker Switchgear Assemblies – Conformance Test Procedures

3. NEMA/ANSI C37.55 American National Standard for Switchgear – Medium Voltage Metal-Clad Assemblies – Conformance Test Procedures

D. National Electrical Safety Code (NESC):

1. IEEE/ANSI C2 National Electrical Safety Code

E. National Fire Protection Association (NFPA):

1. NFPA 70 National Electrical Code

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples for submittal requirements and procedures.

B. Product Data: Submit product data for components specified herein.

C. Design Drawings: Provide design drawings for the 34.5 kV switchgear and associated devices, including equipment layouts and circuit breaker control schematics.

D. Protective relay settings software and C02 panel PLC software ladder logic diagrams.

E. Test plan and procedures for factory testing.

F. Test report for factory testing.

G. Operation and Maintenance Manuals: Provide systems manuals with operation and maintenance manuals in accordance with Section 01 78 23, Operation and Maintenance Data.

H. Record drawings.

I. Equipment and software configuration control logs.

1.06 QUALITY ASSURANCE

A. Electrical components, devices, and accessories shall be listed and labeled in conformance with NFPA 70, Article 100.

B. The manufacturer of the 34.5 kV AC switchgear and 34.5 kV circuit breakers shall have a minimum of 5 years of successful and proven transit, industrial or utility experience in providing equipment similar to the one specified herein.

C. The manufacturer of the AC switchgear's auxiliary equipment, devices and components shall have a minimum of five years of successful and proven design and manufacturing experience in the transit industry, providing equipment similar to the one to be furnished under this Contract.

1.07 DELIVERY, STORAGE AND HANDLING

A. Equipment shall be weatherproofed for shipment. Connection openings shall be closed to prevent entrance of foreign material during shipment and storage.

B. Equipment shall be handled and stored in conformance with manufacturer's instructions. One copy of these instructions shall be included with the equipment at time of shipment.

1.08 GENERAL REQUIREMENTS

A. Refer to Contract Specifications Section 34 21 01, General Requirements for the Traction Power System for general requirements.

1.09 SPARE PARTS, TEST EQUIPMENT AND TOOLS

A. Mandatory Spare Parts: For each substation delivered, furnish the following mandatory spare parts to maintain and operate the 34.5 kV metal-clad type switchgear with the requirements of Section 01 78 44, Spare Parts and Maintenance Materials.

1. Two Integrated Protection Relays (IPR) as described below
2. One 34.5 kV circuit breaker as described below
3. 10 percent spares of fuses, indication lights, and control power circuit breakers

B. Recommended Spare Parts: Provide a recommended list of spare parts required to maintain and operate the facility power system in accordance with the requirements of Section 01 78 44, Spare Parts and Maintenance Materials.

PART 2 – PRODUCTS

2.01 GENERAL

A. The functions of the AC switchgear assembly in each traction power facility are as described below.

1. In switching stations, the 34.5 kV switchgear receives three-phase, 60 Hz, 34.5 kV power from the high-voltage 230, 115, 60/34.5 kV substation and distributes it by means of two 34.5 kV sub-transmission feeders to the traction power substations installed along the tracks, as indicated. In certain switching station locations, the AC switchgear is provided with an additional circuit breaker, which supplies power to auxiliary substations feeding the subway ventilation system.

2. In Traction Power Substations (TPSS), the 34.5 kV switchgear receives power from the two sub-transmission feeders and distributes it to two transformer rectifier units via sectionalized bus. Each 34.5 kV feeder is terminated on the line side of a circuit breaker, whose load side is connected to a rectifier transformer. A normally open bus-tie circuit breaker is provided, also connected between the load sides of the two feeder circuit breakers. The feeder circuit breakers are normally closed.

3. In sectionalizing stations, the AC switchgear divides the 34.5 kV sub-transmission system between adjacent high-voltage substations into line sections and provides the capability to connect the two adjoining line sections during outage of either high-voltage substation.

B. The AC switchgear shall form a lineup of dead-front, free standing sheet metal cubicles. The AC switchgear and associated auxiliary cubicles shall be of the metal-clad construction, and designed and fabricated in accordance with IEEE C37.20.2 and NEMA C37.51.

C. The AC switchgear shall be housed in an outdoor, walk-in type, transportable prefabricated house, as specified in Section 34 21 05, Prefabricated AC and DC Equipment Houses, or in an equipment room located within a passenger station or other facility. The AC switchgear shall include draw-out circuit breakers, three-phase bus and bus connections, cable terminations, instrument transformers, indicating devices, protective and auxiliary relays, terminal blocks, control circuitry, interlocks, switches, and all other equipment, panels, and devices as indicated for a complete operating installation.

2.02 OPERATING REQUIREMENTS

A. The 34.5 kV circuit breakers shall be provided with both local and remote control, and monitoring.

B. At the switching stations, the 34.5 kV circuit breakers shall be normally closed to keep both sub-transmission feeders energized under normal operating conditions.

C. At the sectionalizing stations, the 34.5 kV circuit breakers shall be normally open.

D. At each TPSS, operation of the circuit breakers shall be as follows:

1. Under normal operating condition, the two 34.5 kV feeder circuit breakers shall be normally closed and the 34.5 kV bus tie circuit breaker shall be normally open. The line side of each feeder circuit breaker shall be connected to the incoming 34.5kV sub-transmission feeder and the load side connected to the rectifier transformer.

2. The two 34.5 kV feeder circuit breakers and the bus tie circuit breaker shall be equipped with automatic transfer scheme (ATS) such that upon loss of power on either one of the incoming 34.5 kV sub-transmission feeders, after a programmable short time delay (as approved by the Engineer), it will automatically trip the affected 34.5 kV feeder circuit breaker and automatically close the normally open 34.5 kV tie circuit breaker. No paralleling of the two 34.5 kV feeder circuit breakers will be allowed and no automatic transfer will be permitted if there are any system faults (i.e., phase to phase or phase to ground or phase current unbalanced).

3. During manual operation, the 34.5 kV feeder and the bus tie circuit breakers shall have the capability to operate with one feeder circuit breaker closed and the bus tie circuit breaker closed. Controls shall be designed to allow only two out of three circuit breakers to be closed at any one time.

2.03 RATINGS

A. The AC switchgear ratings shall be in accordance with IEEE C37.06 and NEMA SG 4, and shall be as follows:

1. Nominal Voltage, Line-to-Line: 34.5 kV, rms

2. Rated Max Voltage: 38 kV, rms

3. Rated Low Frequency Withstand: 80 kV, rms

4. Rated Full Wave Impulse Withstand: 150 kV, rms

5. Rated Frequency: 60 Hz

6. Rated Continuous Current: 1200 A, rms

B. AC circuit breakers shall be rated in accordance with IEEE C37.06 and NEMA SG 4 and shall have the following minimum ratings:

1. Rated Short-Circuit Current at Rated Max kV: 21 kA, rms

2. Breaker Rated Voltage Range Factor, K: 1.65

3. Breaker Rated Interrupting Time: 5 cycles

4. Breaker Rated 3-Sec Short-Time Current Carrying Capability: 35 kA, rms

5. Breaker Rated Closing and Latching Capability: 95 kA, rms

6. Rated Max Voltage: 38 kV

2.04 SWITCHGEAR ENCLOSURE

A. Switchgear assemblies for circuit breakers and associated instrument transformers and relaying shall be of the metal-clad type and shall form a line-up of dead-front, freestanding cubicles. Each cubicle shall consist of several compartments to house the circuit breaker, bus bars, cables, relays and devices as indicated. Circuit breakers shall be installed in the bottom compartments of the respective cubicles.

B. Each cubicle shall be a rigid, self-supporting, self-contained, electrically welded or bolted steel structure enclosing all sides and top, except openings for specific purposes. The structure shall support equipment under normal and short-circuit conditions.

C. Panels comprising the switchgear enclosure, including the doors, shall be constructed of sheet steel, of thickness not less than No. 11 gauge.

D. Compartments shall be isolated from one another by grounded barriers of not less than No. 11-gauge sheet steel.

E. Each cubicle shall have front and rear hinged doors. Rear doors shall be weatherproof type. At a minimum, the doors shall meet the following requirements:

1. The doors shall support flush and semi-flush mounted devices and not distort from a plane surface in any position. The doors shall be supported by concealed hinges.

2. Each cubicle front hinged door shall have a handle and a mechanical three-point vibration-proof latch for holding it in a closed position.

3. Each cubicle front door shall be provided with a stop to hold the door in the open position, such that door-mounted devices will not touch similar devices mounted on adjacent doors.

4. Doors of the circuit breakers compartments shall be designed to be closed and locked when the breaker is in the CONNECTED, TEST or DISCONNECTED position.

5. Both the front and rear doors shall have provisions for padlocking.

F. Each circuit breaker cubicle shall be provided with protective shutters that automatically close and cover the live high-voltage terminals, as the removable breaker element is racked out.

G. Breaker compartments shall be constructed so that the circuit breakers may be drawn in and out of their housing on wheels, along guide ways, and make connections to the buses and auxiliary circuits by means of self-aligning, self-coupling primary and secondary disconnecting devices.

H. Bus compartments shall be of rigid framework and shall include bus work, connection bars, cable terminal connectors, bus and cable supports.

I. To facilitate cleaning and inspection, removable cover plates with lifting handles shall be provided for bus compartments to allow access to the bus and cable connections with cables in place. Plates shall be metallic, shall be less than 18 by 24 inches in size, shall have no sharp edges, and shall weigh less than 20 lbs. each.

J. Provide bottom cable entrance for external power and control terminations, unless top entries are shown on the Contract Drawings. At indoor TPSS, cable entrance shall be top entry. Ample space shall be provided for cable pulling, cable termination and performing high potential tests on cables without having to remove the terminations from the cubicle.

K. Switchgear assembly items requiring inspection, operation or maintenance shall be installed no higher than 72 inches off of the floor, and shall be accessible from the front and back end of the switchgear.

L. The switchgear cubicle shall contain louvers with filters preventing ingress of foreign particles and provide adequate ventilation and air cooling of the components inside. Louver design shall be coordinated with the specified ventilation system for the prefabricated switchgear house. Ventilation intake openings shall neither be located less than six inches above the floor, nor where they would allow entry of debris and dirt.

M. The racking mechanism to move a circuit breaker between CONNECTED and TEST positions shall be accessible and operable with the front door closed and latched. When the breaker door is closed and the breaker is fully withdrawn, there shall be adequate electrical and mechanical clearance between the breaker and the door-mounted devices. A remote racking motor with a 20 foot long cable and control station shall be provided so that the breakers can be racked in or out electrically without requiring to stand in front of the breaker cubicle. Each breaker door shall have provision to mount the remote racking motor assembly. A receptacle to provide power for the motor shall be provided on each breaker cubicle door.

2.05 CIRCUIT BREAKERS

A. General:

1. The circuit breakers shall be sealed vacuum type, and shall be rated in accordance with IEEE C37.04 and IEEE C37.06. Circuit breaker design shall incorporate the following features:

    a. The circuit breakers shall be three-pole, single-throw, stored-energy operating type, rated for service on a three-phase, effectively grounded-neutral, 60 Hz system at a nominal operating voltage of 34.5 kV line-to-line.

b. The circuit breaker control circuits and stored-energy mechanism charging motor shall operate from a 125 V DC source.

c. Removable breaker elements of the same type and rating shall be completely physically and electrically interchangeable. Removable elements of different type or ratings shall not be interchangeable.

d. The circuit breakers shall close over a control voltage range from 90 V DC to 140 V DC, and trip over a control voltage range from 75 V DC to 140 V DC.

e. Each circuit breaker shall have a full front metal shield that will make it possible to access and maintain the operating mechanism from the front of the circuit breaker while it is installed in its cell. The circuit breaker frame shall be continuously grounded whenever it is installed in the cubicle by using a sliding contact on the circuit breaker that mates with a ground bar in the bottom of circuit breaker cell. The front metal shield shall serve to enclose the circuit breaker in its own grounded metal compartment when the circuit breaker is in the fully connected position.

2. Circuit breakers shall be designed to interrupt the rated short-circuit current in a sealed vacuum with a separate vacuum chamber for each phase of the circuit breaker:

a. Contact erosion indication shall be provided on each interrupter pole assembly, for evaluation of wear on the main contacts over the life of the circuit breaker.

B. Circuit Breaker Positions:

1. Provisions shall be made for moving the circuit breaker to and from a CONNECTED, TEST and DISCONNECTED position. The three positions shall be clearly marked on the floor of the switchgear cubicle cell, clearly visible through a viewing window.

2. In the CONNECTED position, both the primary and secondary disconnecting devices shall be in full contact and the breaker shall be in position for normal operation.

3. In the TEST position, the primary disconnecting devices shall be open and separated by a safe distance to prevent arcing, while the secondary disconnecting devices shall be in full contact. Automatically operated shutters shall cover the exposed part of the bus and main stationary contacts.

4. In the DISCONNECTED position, both the primary and secondary disconnecting devices shall be open and separated by a safe distance.

C. Operating Mechanism:

1. The circuit breaker shall be operated by a motor charged stored-energy mechanism, and shall be spring type, mechanically and electrically trip-free, and non-pumping. Circuit breaker design shall include provisions for manual charging of the stored-energy mechanism. The use of hydraulic or pneumatic operating mechanisms is not acceptable.

2. The operating springs shall discharge automatically when the breaker is rolled out fully from the compartment or is moved into the DISCONNECT position.

3. A closing spring CHARGE/DISCHARGE indicator shall be provided visible on the front of the removable element with the door closed, showing the status of the closing spring.

4. The closing spring shall be recharged automatically once the circuit breaker has been closed.

D. Withdrawal Mechanism:

1. Each switchgear cubicle shall have a cranking or ratcheting device for moving the circuit breaker to and from the CONNECTED, TEST and DISCONNECTED positions.

2. A switch shall be included to disconnect automatically the charging motor circuit during cranking.

3. Guide rails shall ensure alignment of the circuit breaker during insertion and removal. Breaker insertion and withdrawal shall be free of jamming and shall only require an average person to operate.

E. Mechanical Interlocks:

1. Mechanical interlocks shall be provided on each circuit breaker unit to:

   a. Prevent inserting or disconnecting a closed circuit breaker

   b. Discharge the stored energy springs prior to circuit breaker removal, and

   c. Prevent the circuit breaker from closing, if the closing spring is not fully charged.

2. Positive stop shall be provided to prevent over travel of the circuit breaker when moving into the CONNECTED position and the TEST positions.

3. A flag indicator, visible when the cubicle door is closed, shall be provided to indicate when the breaker is in TEST or CONNECTED positions.

F. Disconnecting Devices:

1. Each circuit breaker shall be equipped with primary and secondary disconnecting devices.

2. Stationary and potentially energized parts of the primary disconnecting devices shall be covered automatically by safety shutters, when the circuit breaker is racked away from the CONNECTED position to the TEST or DISCONNECTED position. The shutters shall be operated by direct mechanical linkage to the floor-mounted racking mechanism, and shall be capable of withstanding the force of the circuit breaker in case of failure of the shutters to open when the breaker is racked into position. The shutters shall be designed to remain closed until they are opened by the presence of the circuit breaker.

3. Primary disconnecting devices shall:

   a. Provide electrical continuity between the stationary contacts in the housing and the corresponding circuit breaker terminals.

   b. Be located and mounted to maintain alignment during breaker insertion or withdrawal, and

   c. Have silver-plated contact surfaces.

G. Circuit Breaker Controls:

1. A control switch shall be provided on the front door of each breaker unit for electrical tripping of the breaker in any position, and closing it only in the TEST position.

2. A LOCAL-REMOTE selector switch shall be provided on the front door of each breaker unit for electrical closing of the breaker in the connected position. When using this function, the close shall be actuated with a programmable time delay.

3. For traction power substations: Manual local control of the breaker shall be capable when the C02 LOCAL-REMOTE selector switch is in the LOCAL position and the AC breaker is in the CONNECTED position. Local control shall be capable of operating circuit breakers when the C02 main PLC or C04 Ethernet switch is inoperable.

4. For switching and sectionalizing stations: Manual local control shall be capable when the C02 LOCAL-REMOTE selector switch is in the LOCAL position and the AC breaker is in the CONNECTED position. Local control shall be capable of operating circuit breakers when the C02 main PLC or C04 Ethernet switch is inoperable.

5. For switching and sectionalizing stations, an input and output (I/O) module shall be installed in the C02 panel and the other of the matching pair shall be installed with the AC switchgear lineup. I/O module may be wired directly to more than one AC circuit breaker IPR.

6. Provide each circuit breaker with a manually-operated mechanical means for tripping the circuit breaker when in the TEST and CONNECTED positions, and closing the breaker when in the TEST position only. When in the TEST position the circuit breaker shall be operable only from the control switch mounted on the cubicle door.

7. Design circuit breakers for remote control operation as specified in Section 34 21 33, Control, Monitoring and Display Panel. Remote commands shall be able to trip the breaker at all times while in the connected position, but shall be able to close it only when the LOCAL-REMOTE selector switch located at the C02 panel and the LOCAL-REMOTE selector switch (Local) on the front of each circuit breaker unit are in the REMOTE positions.

8. Controls for the 34.5 kV circuit breakers shall be interlocked with the rectifier doors in the TPSS, such that any door opening shall trip the main and tie circuit breakers connected to their respective transformer-rectifier unit. The protective relay logic and interlocking shall permit operation of the substation with one transformer-rectifier unit only, while the other unit is out-of-service due to fault or maintenance.

9. Provide remote SCADA indications to the Operations Control Center for the open position status, closed position status, and CONNECTED/TEST/DISCONNECTED position for each 34.5 kV circuit breaker and Remote indications of both local and station selector switches.

10. A minimum of ten electrically separate reversible auxiliary spare contacts shall be provided, in addition to those required for the circuit breaker control circuit.

11. Auxiliary contacts external to the circuit breaker (MOC) shall be operated by the breaker mechanism in both the CONNECTED and the TEST positions.

12. Auxiliary contacts including spares shall be wired to the terminal blocks and properly labeled.

13. Six-digit operation counter shall be provided to record tripping operations.

14. Circuit breakers shall be equipped with padlocking provisions in the DISCONNECTED position.

H. Circuit Breaker Status Indications:

1. The open and close status of the breakers shall be indicated, respectively, by green and red lights mounted on the control panels and by mechanical flag indicators:

   a. The red BREAKER CLOSED indicating light and auxiliary relay for remote indication shall be connected to monitor the continuity of the trip circuit.

   b. The indicating lights and the mechanical flags shall be visible when the circuit breaker compartment door is closed.

2. A flag indicator, visible when the door is closed, shall be provided to indicate the position of the circuit breaker (i.e., CONNECTED, TEST or DISCONNECTED).

3. Dry auxiliary contacts mounted on the circuit breaker and wired to terminal blocks shall be provided for remote breaker status and position indications.

2.06 BUSES AND BUS CONNECTIONS

A. The 34.5 kV buses shall be made of rigid copper bars and shall be of sufficient size to carry the continuous rated current, without exceeding the temperature limits indicated in IEEE C37.20.2. The continuous rating of bus and bus connections shall be 1200 amperes.

B. The phasing of the power provided is counterclockwise, such that the A is 0 degrees, B is 240 degrees, and C is 120 degrees. The phase sequence of three-phase assembled buses and primary conductors shall be A-B-C counting from front to back, top to bottom, or left to right as viewed from the front side of the switchgear assembly.

C. The buses shall be supported and braced between each other and to the enclosure with high strength anti-hygroscopic, flame-retardant, non-tracking insulators, so that the buses withstand the thermal and mechanical stresses due to maximum short-circuit currents equal to the maximum symmetrical interrupting and three-second short time current ratings of the circuit breaker protecting the bus.

D. Bus bars including runbacks shall be insulated with track-resistant, flame-retardant epoxy coating. Bus joints shall be insulated with flexible or molded removable resin boots. The method of bus insulation and materials shall conform to IEEE C37.20.2.

E. Bus joints and connections shall be of the bolted construction. They shall:

1. Be acid-etched and plated with electro-deposited silver after buses have been bent or formed. Bending after the plating process will not be allowed.

2. Be made with Belleville-type washers and high-strength, rust resistant steel bolts, such as cadmium-plated or galvanized. Bolt shall be capable of being properly torqued and locked in place.

F. Bus joints shall have conductivity at least equal to that of the bus bars, and each joint shall be so clamped such that no loss of conductivity will occur during the life of the equipment.

G. Access plates shall permit assembling of joints and inspection of bolted connections after installation of the bus enclosure.

2.07 GROUNDING

A. A copper ground bus with a symmetrical withstand current rating equal to that of the circuit breaker shall extend throughout the entire length of the switchgear assembly. Ground bus shall not be less than 1/4-inch by 2-inches in size.

B. At least two 9/16-inch diameter holes at 1-3/4-inch centers shall be provided at each end of the bus.

C. Provide grounding knobs on the ground bus and on each phase bus for safety grounding of the incoming 34.5 kV cables and phase buses. The grounding knobs shall be provided with removable insulated caps for the grounding device.

D. The frame of each circuit breaker shall be grounded directly through a high-current ground contact shoe, when the circuit breaker is in the CONNECTED or TEST positions.

E. Each cubicle shall be grounded directly to the ground bus. Cubicle doors and panels shall be provided with a flexible copper braid ground strap attached to the structure framing.

F. Grounding connections shall be metal-to-metal, with any nonconductive coatings such as paint or lacquers removed to ensure solid electrical contact.

G. The ground bus shall have provisions for connecting ground cables in each cubicle and at the ends of the switchgear lineup.

2.08 125 VOLT DC CONTROL POWER

A. Control power for circuit breaker closing and tripping functions, and for energizing control, indication, monitoring and protective devices shall be from the 125 V DC control power as specified in Section 34 21 40, DC Control Power System.

B. A two-conductor AWG No. 6 or larger, 125 V DC control bus with a minimum 600 V insulation shall be provided for the full length of each switchgear assembly.

C. The control bus shall:

1. Run in a protective raceway,

2. Terminate on a terminal block for connection to the power supply source; and

3. Be tapped at each cubicle served and extended to the associated circuit breaker control compartment.

D. Molded-case, thermal magnetic circuit breakers shall be provided for protection and isolation of each control circuit in each switchgear cubicle.

E. Control power voltage-monitoring relay shall be provided and connected on the load side of the molded-case circuit breaker in each switchgear cubicle.

2.09 120 VOLT AC POWER

A. A 120 V AC, 60 Hz, No. 2 AWG or larger two-wire bus shall be provided for devices such as heaters, fans, lights, and receptacles.

B. The AC bus shall:

1. Extend for the full length of each switchgear assembly;

2. Terminate on a terminal block for connection to an external power supply; and

3. Be tapped in each switchgear cubicle for connections of space heaters, fans, lights and receptacles. Lighting circuits shall be independent from other circuits.

2.10 TERMINATIONS

A. Unless otherwise indicated, power cables shall enter and leave the switchgear at the bottom. Provisions shall be made to accommodate the number of cables indicated.

B. The bus connections for the 34.5 kV single-conductor power cables shall be coordinated with the size of the cable terminations and shall not be located lower than 24 inches above the switchgear floor if the power cables are entering from below.

C. 34.5 kV power cable terminations shall be as specified in Section 34 22 23, Traction Power Cables. NEMA 2-hole cable connections shall be provided for the cable size indicated.

D. Low voltage terminations shall be as specified in Section 34 21 50, Common Materials and Methods for Traction Power.

2.11 EQUIPMENT PROTECTION

A. Relaying, metering and indicating devices shall be provided as indicated. Refer to Section 34 21 50, Common Materials and Methods for Traction Power, for general requirements of protective relays and indicating devices.

B. Provide control and indication functions in accordance with Contract Specifications Section 34 21 33, Traction Power Control, Monitoring, and Display Panel and Related Equipment.

C. Equip each 34.5 kV feeder circuit breaker and bus tie circuit breaker with a microprocessor-based multi-function protection relay, referred to as an IPR as specified in Section 34 21 12, Integrated Protection Relay Equipment for AC Circuit Breakers for High Voltage and Traction Power Substations; and Section 34 21 13, Integrated Protection Relay Equipment for AC Circuit Breakers for Switching Stations and Sectionalizing Stations.

D. At traction power facilities using 34.5 kV switchgear, IPRs shall be used for protection and circuit breaker control. Provide protection functions as indicated.

E. Overcurrent Protection:

1. For switching and sectionalizing stations provide backup controls described in Article 2.05G.4 and 5 in addition to the primary control and protection devices. If an equipment or cable phase or ground fault occurs, the corresponding 34.5 kV feeder circuit breakers shall be tripped directly by primary or back-up protection devices, or through its corresponding lockout relay, device 286, as indicated on the Contract Drawings. If there is any failure in the fiber optic cable associated with the protection relay, the 34.5 kV circuit breakers 252-11, 252-12 and bus tie circuit breaker 252-13, or 252-3 and 252-4 shall be tripped through back-up remote I/O modules.

2. At traction power substations if a phase or ground fault occurs on a 34.5 kV transformer-rectifier circuit, the corresponding 34.5 kV feeder circuit breaker and 34.5 kV bus tie circuit breaker shall be tripped directly by its primary or back-up protection devices, or through its corresponding lockout relay, device 286, as indicated on the Contract Drawings.

F. Control and Communications Functions:

1. Coordinate the C02 panel to implement controls, indications, and data transfer between the IPR relays and the C02 panel for local and remote control, indication, and data transfer functions and processes. Communication between IPR relays and the C02 PLC shall use the DNP3 protocol.

2.12 INSTRUMENT TRANSFORMERS

A. Instrument transformers shall conform to IEEE C57.13 and NEMA C12.11. The current and potential transformers shall comply with the ANSI/IEEE relays and metering accuracy standards, and shall have 0.6 accuracy class or better, under the burdens imposed by the connected services. This accuracy limit does not apply to revenue metering which is described below.

B. Instrument transformers shall be insulated for 38 kV voltage class and shall have basic impulse insulation level of 200 kV full-wave.

C. Current transformers (CTs) shall be dry type, of molded rubber or epoxy construction, multi-ratio, bushing, toroidal or wound-type:

1. Ratio and phase-angle characteristics of CTs shall be suitable for the relaying or metering, as indicated.

2. CTs shall be installed in a manner such that they are easily accessible for inspection and maintenance.

3. In TPSSs and switching stations, each feeder and tie circuit breaker cubicle shall be provided with two CTs per phase rated 1200/5A. In sectionalizing stations, each circuit breaker cubicle shall be provided with one CT per phase rated 1200/5A as indicated.

4. CTs and their secondary wiring shall be protected from induced voltages by metallic shielding. Secondary wiring shall utilize No. 10 AWG copper wire and shall be run to readily identifiable terminal blocks in the breaker control compartment. The terminal blocks for the CTs shall be suitable for ring type wire connections, shall have covers, and shall feature integral shorting bars for the CT leads.

5. CTs shall be capable of withstanding thermal, magnetic and mechanical stresses from the flow of current equal to the interrupting and momentary routings of the circuit breakers.

6. CTs for revenue metering or power monitoring applications shall be 0.15 percent across burden classes B1 through B8 as defined by IEEE C57.13.6.

D. Potential transformers (PTs) shall be of the molded rubber or epoxy-encapsulated construction, with primary current-limiting fuses mounted on integral drawout carriage as indicated:

1. PTs shall be mounted in a dedicated compartment and shall be easily accessible for inspection and maintenance, either from the front or rear of the cubicle. Upon opening of the dead-front door, the primary fuses and PTs shall be automatically disconnected and shall be visibly grounded.

2. Primary and secondary circuits of PTs shall be protected by means of non-renewable cartridge type fuses. Secondary circuit fuses shall be installed in the low voltage circuits of the PTs and shall be located such that it permits replacement when the switchgear is in service.

3. PTs shall have voltage ratio of 20,125 V primary to 115 V secondary, and shall be connected between phase A and neutral, phase B and neutral, and phase C and neutral.

4. PT disconnecting means shall use umbilical cord type disconnecting hardware. Minimum cord length shall be 36 inches.

5. PTs for revenue metering application shall be 0.15 percent across burden classes W to ZZ as defined by IEEE C 57.13.6.

2.13 APPURTENANCES AND AUXILIARY DEVICES

A. AC switchgear appurtenances and auxiliary devices, such as control switches, wiring devices, low voltage wires and cables, and indicating lights shall be as specified in Section 34 21 50, Common Materials and Methods for Traction Power.

2.14 MAINTENANCE ACCESSORIES DEVICES

Provide the following accessories for each AC switchgear assembly:

A. Wall mounted test cabinet with necessary equipment for testing a 34.5 kV AC circuit breaker after it has been removed from the cubicle.

B. Necessary equipment needed for the normal operation and preventive maintenance of the circuit breaker, such as manual charging handle and manual racking crank handle. One set of fuse tongs or hooksticks for replacement of high-voltage fuses, depending on the requirements.

C. Test cable of minimum 6-feet in length for each switchgear assembly to permit operating a circuit breaker when completely removed from its compartment. This cable will be required to connect the control circuits of the compartment to the control circuits of the withdrawn breaker and to operate the breaker without the use of the test cabinet.

D. One set of wrenches required for the primary disconnecting devices of the circuit breaker, and two sets of screwdrivers and other hand tools required for obtaining access to the AC switchgear and replacement of any equipment or device in the AC switchgear. Tools shall be insulated type.

E. A cable-type grounding device for grounding dead bus of the switchgear. The device shall be operated by a hot-stick and shall meet ASTM F855 requirements. A wall-mounted storage panel shall be provided for the grounding device and the hot-stick.

2.15 FACTORY TESTING

A. General: Testing shall be performed in accordance with the requirements of Section 01 45 24, Testing Program Requirements.

B. Factory Tests:

1. The following design tests shall be performed on one AC switchgear assembly, complete with associated 34.5 kV AC circuit breakers:

   a. Applicable tests identified as design tests in IEEE C37.09 for the circuit breaker.

   b. Applicable tests identified as design tests in IEEE C37.20.2 and IEEE C37.55 for the switchgear assembly.

   c. Performance verification tests on switchgear control circuits including automatic transfer.

2. The following production tests shall be performed on AC switchgear assemblies, complete with their associated 34.5 kV AC circuit breakers:

   a. Applicable tests identified as production tests in IEEE C37.09 for the circuit breakers.

   b. Applicable tests identified as production tests in IEEE C37.20.2 and IEEE C37.55 for the switchgear assemblies.

   c. Functional tests on switchgear control circuits including automatic transfer between the substation 34.5 kV main circuit breakers and bus tie circuit breaker.

2.16 TRACTION POWER FACILITY SYSTEM FACTORY FUNCTIONAL TESTING

A. Refer to Section 34 21 75, Traction Power Facility System Factory Functional Testing for requirements.

PART 3 – EXECUTION

3.01 FIELD ACCEPTANCE TESTING

A. Refer to Section 34 21 80, Traction Power System Field Acceptance Testing for requirements.

END OF SECTION 34 21 18

SECTION 34 21 19

SEPARABLE INSULATED CONNECTOR

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Separable insulated connector assembly.

B. 35 kV elbow termination enclosures.

C. Existing switchgear cable termination and bus modifications.

1.02 RELATED SECTIONS

A. Refer to the following Sections for requirements:

1. Section 01 33 00 Submittal Procedures
2. Section 01 33 23 Shop Drawings, Product Data, and Samples
3. Section 01 43 00 Quality Assurance
4. Section 01 45 00 Quality Control
5. Section 01 45 24 Testing Program Requirements
6. Section 01 74 14 Cleaning
7. Section 01 78 23 Operation and Maintenance Data
8. Section 01 77 00 Closeout Procedures
9. Section 01 78 39 Project Record Documents
10. Section 34 21 01 General Requirements for the Traction Power System
11. Section 34 21 05 Prefabricated AC and DC Equipment Houses
12. Section 34 21 70 Traction Power Facilities Installation Requirements
13. Section 34 21 80 Traction Power System Field Acceptance Testing
14. Section 34 22 23 Traction Power Cables

1.03 MEASUREMENT AND PAYMENT

A. Separate measurement and payment will not be made for work required under this Section. All costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work.

1.04 REFERENCE STANDARDS

A. Activities shall be in accordance with the following codes, standards, and specifications except as provided herein. Where requirements conflict with requirements specified herein or elsewhere in the Contract the more restrictive requirements shall apply.

B. Association of Edison Illuminating Companies (AEIC):

1. AEIC CS8 Specifications for Extruded Dielectric, Shielded Power Cables Rated 5 through 46 kV

C. Insulated Cable Engineers Association (ICEA):

1. ICEA S-94-649 Concentric Neutral Cables Rated 5 through 46 kV

D. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE 386 Separable Insulated Connector Systems for Power Distribution Systems Rated 2.5 kV through 35 kV

2. IEEE 404 Extruded and Laminated Dielectric Shielded Cable Joints Rated 2.5 kV to 500 kV

E. National Electrical Manufacturers Association (NEMA):

1. NEMA C119.4 Electrical Connectors – Connectors for Use between Aluminum to Aluminum and Aluminum to Copper Conductors Designed for Normal Operation at or Below 93°C and Copper to Copper Conductors Designed for Normal Operation at or Below 100°C

F. Underwriters Laboratories Inc. (UL):

1. UL 486 A & B Standard for Safety Wire Connectors

1.05 SUBMITTALS

A. Refer to the following Sections for additional requirements:

1. Section 01 33 00 Submittal Procedures

2. Section 01 33 23 Shop Drawings, Product Data, and Samples

3. Section 01 78 23 Operation and Maintenance Data

4. Section 34 21 01 General Requirements for the Traction Power System

5. Section 34 21 80 Traction Power System Field Acceptance Testing

B. Shop Drawings: Submit the following Shop Drawings:

1. Separable insulated connector section details for materials and assembly construction.

2. Connector and cable terminations showing cross sections, dimensions, and installation details.

3. Installation details for the 35 kV elbow termination enclosures showing overall dimensions and clearances, U-Channel support details, mounting details, cable routing and outline dimensions and tolerances, installation details, and grounding installation details.

C. Product Data: Submit data for 35 kV elbow termination enclosures, separable insulated connector assembly and associated materials including junction bars, connectors, insulated bushing with standard brackets, protective caps with drain wires, special installation tools, and accessories. Product data shall include product description, bill of materials, and detailed technical specifications.

D. Samples

1. Provide one (1) sample of each type of separable insulated connector assembly that includes the connector (plug), junction bar with the parking stand, grounding components, and insulated protective covers.

2. Samples shall be labeled with the following data: name of the manufacturer, type, model, size, voltage rating, insulation, application, and use.

3. Before submitting the sample, ensure that the product will be available in the quantities required for the Contract. No change or substitution will be permitted after submittal of the samples.

4. Product incorporated in the work shall match the approved samples.

E. Certificates from manufacturers verifying that equipment conforms to specified requirements.

F. Material safety data sheets.

G. Factory acceptance test documentation (e.g. test plan and procedures, data sheets, reports) per Section 01 45 24, Testing Program Requirements. Manufacturer shall certify factory design and production test reports indicating compliance of connector assemblies and enclosures with referenced Standards and these specifications.

H. Assembly, Installation, Termination and Connection, and Testing Manuals:

1. Provide a detailed written narrative describing the installation, termination and connection methods, manufacturer recommended field testing procedures and maintenance instructions for the separable insulated connector assembly to be furnished. Drawings, sketches, part numbers, sources of special tools, gauges, handling equipment required, and other pertinent information shall be included in the manual. Manual format and contents shall conform to the requirements for operation and maintenance manuals as defined in Section 01 78 23, Operation and Maintenance Data.

2. Draft versions of the manuals for the separable insulated connector assembly shall be submitted for approval. Final versions of manuals shall be submitted 30 Days after receipt of District's comments and not less than 60 Days prior to connector installation in the field.

3. The manual shall include at a minimum the following:

   a. Site storage instruction including handling and storage requirements for short and long term.

   b. Installation equipment checklist, equipment set-up with diagram, illustrations, and sketches.

   c. Connector terminations and connections to 35 kV EPR cables.

   d. Instrumentation and procedures for field testing after connection to cables and termination to the junction bars.

I. Installation verification and field functional test documentation (e.g. procedures, data sheets, reports) per Section 34 21 80, Traction Power System Field Acceptance Testing.

J. Spare Parts List. One (1) separable connector with test point, plug, insulated cover, grounding elbow, adjustable bracket with three insulated parking bushing for every three 200A elbow connectors and every three 600A elbow connectors.

1.06 QUALITY CONTROL, QUALITY ASSURANCE AND SUPPLIER QUALIFICATIONS

A. Refer to Section 34 21 01, General Requirements for the Traction Power System, and Section 34 21 70, Traction Power Facilities Installation Requirements, for requirements.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 34 21 70, Traction Power Facilities Installation Requirements, for requirements.

1.08 GENERAL REQUIREMENTS FOR THE TRACTION POWER SYSTEM

A. Refer to Section 34 21 01, General Requirements for the Traction Power System, for requirements.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

A. The separable insulated connectors shall be manufactured by any of the following:

1. Eaton Power Systems
2. Thomas & Betts
3. Elastimold
4. The Durham Company
5. Or equal.

2.02 SEPARABLE INSULATED CONNECTOR ASSEMBLY

A. General: Separable insulated connector assembly shall be provided for 35.4kV power circuits. The connector assembly shall be factory mounted and housed in an enclosure. Provide suitable connector assembly enclosures as needed. Enclosure type shall either be suitable for aerial installation or shall be free standing type for at grade installation. The elbow termination box or enclosure is specified herein Article 2.02C.

B. Separable Insulated Connector Assembly

1. Separable insulated connector system shall consist of in-line and Y-splice junction bars, bushing wells, bushing inserts, elbow and straight connectors (Plugs), grounding elbows, parking stands, mounting brackets, and accessories.
2. The connector system shall be submersible, made of vacuum cast resin, and shall meet all the requirements of IEEE 386.
3. Elbow connector assembly shall be 35 kV, 200A loadbreak type and provided with test point and operating eye, (used for TPSS connection to elbow box or IDS). Straight connector assembly shall be 600A deadbreak type (used for TPSS IDS to TPSS IDS connections).
4. Elbow and straight connector assemblies shall be sized as indicated EPR shielded cable.

5. The 200A loadbreak elbow connector assembly shall be rated for 150 kV BIL, 50 kV AC one minute withstand, 103 kV DC 15 minute withstand, 26 kV Corona Extinction, 10 kA rms symmetrical for 0.17 second and 3.5 kA rms symmetrical for 3 seconds.

6. The 600A deadbreak straight connector assembly shall be rated 600A rms continuous, 1 kA rms for 24 hour overload, 25 kA rms symmetrical for 0.17 second and 10 kA rms symmetrical for 3 seconds.

7. The connector assembly shall have an electrically conductive shield and shall have provision for connecting an external ground to the shield.

8. The junctions shall provide for fully rated, insulated, watertight conductor connections between terminals and shall be complete with grounding lugs, manufacturer's standard accessories such as protective caps, stainless steel mounting brackets, and attaching hardware.

9. Junction bars shall be provided with one elbow interface and one parking stand per circuit conductor as indicated.

10. Elbow connector assembly shall be operable by means of a suitable shotgun type live-line hotstick tool that clamps the elbow so that operation is along the probe axis. One hotstick shall be provided for each traction power facility.

C. 35 kV Elbow Termination Enclosure for At-Grade Mounting Installation

1. Provide free standing 35 kV elbow termination enclosures sized as indicated. Each 35 kV elbow termination enclosure shall have factory installed connector assemblies as indicated.

2. The 35 kV elbow termination enclosures shall be of preformed galvanized steel channels, angles, and side sheets braced and welded together to form an outdoor, free standing NEMA 3R metal enclosure, with ventilated front double hinged doors, base, and roof sections. Access doors shall be flanged and shall close against rubber or similar gasketing material. Ventilated openings shall be provided with filtered covers and screened vents for protection against the weather and insects. Doors shall be equipped with latch, stops, and door-locking mechanism and with padlock provisions. The roof section shall be unit construction with openings for 6 inch conduit hubs and connected 6 inch expansion and deflection flex conduits for top cable entry. The enclosure shall form a rigid structure free of mechanical vibration and shall have steel channels or unistruts to mount the connector assembly junction bars and associated components. The base frame shall be provided with mounting holes to allow anchorage to concrete. The enclosure shall be provided with grounding studs for equipment grounding purposes. The interior and exterior surfaces of the enclosure shall be primed and finish painted.

3. 35 kV elbow termination enclosures and associated anchorage shall be designed to meet the seismic requirements as specified in Section 34 21 01, General Requirements for the Traction Power System.

4. The 35 kV elbow termination enclosure shall be prepared, primed, and painted with epoxy paint, color to match the AC equipment house. Refer to Section 34 21 05, Prefabricated AC and DC Equipment Houses and Related Equipment, for additional requirements.

5. The finished elbow termination enclosure shall meet the specification seismic requirements. Requirements shall be confirmed through testing or calculation.

6. The enclosure shall be provided with grounding bus bar installed as indicated.

7. Provide adjustable cable supports as indicated.

8. A nameplate shall be provided in the front of each enclosure. Show from and to for the connected circuit.

9. “Danger High Voltage” warning signs shall be placed on panels and doors.

10. Refer to the Contract Drawings and Section 34 21 70 for additional identification requirements.

D. Grounding:

1. Provide copper ground bus and lugs within T-tap and elbow termination enclosures and ground each cable concentric neutral. Provide separate NEMA two hole ground lugs for 250 kcmil ground wires and connect to existing facility ground grid. Provide two ground connections between enclosure ground bus and facility ground grid for each enclosure.

E. Accessories:

1. One set of three 200A grounding elbow assemblies for each traction power facility site using separable insulated connector assembly enclosures.

2. One set of three 600A grounding elbow assembly for each traction power facility site using separable insulated connector assembly enclosures.

3. For each elbow assembly enclosure provide one set of manufacturer’s standard accessories including three 200A and three 600A protective caps, stainless steel mounting brackets, and attaching hardware.

2.03 FACTORY ACCEPTANCE TESTING:

A. Factory Testing:

1. Separable Insulated Connector Systems:

a. The following production tests shall be performed in accordance with IEEE 386 by the manufacturer on connector components, except ground bushings and grounding elbows:

1) Partial discharge test.

2) AC withstand or full-wave impulse withstand voltage.

3) Test point voltage test.

b. The design tests listed in Table 8 of IEEE 386 shall be performed by the manufacturer to demonstrate compliance of the design with the standard. In lieu of performing the actual tests, certified test results of previous design tests of identical connector components are acceptable.

PART 3 – EXECUTION

3.01 GENERAL

A. Refer to Section 34 21 70, Traction Power Facilities Installation Requirements, for requirements.

3.02 WIRING WORK

A. Refer to Section 34 22 23, Traction Power Cables, for requirements.

3.03 FOUNDATION COORDINATION

A. Examine foundations, anchor bolts, levelling channel, and exposed grounding embed conditions for compliance with the approved Shop Drawings and vendor's requirements prior to placement of the 35 kV elbow termination enclosures.

B. Note items that may infringe on the necessary clearances and other non-compliances. Promptly bring noted issues to the attention of the Engineer for direction and approval before proceeding.

C. Provide corrective actions, as required, shall be undertaken by the Contractor at no cost to the District.

3.04 35 KV ELBOW TERMINATION ENCLOSURE

A. Provide anchor bolts and anchorage items as required, and field check to ensure proper alignment and location. Provide templates, layout drawings, and supervision at the Jobsite to ensure correct placing of anchorage items in concrete. Check embedded items for correctness of location and detail before concrete is placed.

B. Minimum working platform in front of the enclosure shall be 6 feet wide.

C. Confirm 35 kV elbow termination enclosures and associated materials are in conformance with the approved Shop Drawings prior to placement.

D. Install the 35 kV elbow termination enclosures on the foundation secure, level with stainless steel shims (if required), plumb and in true alignment with related adjoining work. Secure the 35 kV elbow termination enclosures to the foundations in accordance with equipment vendor's recommendations and the approved seismic design.

E. Install supporting members, fastenings, framing, hangers, brackets, straps, bolts, and angles as required to set and rigidly connect the 35 kV elbow termination enclosures.

F. Provide temporary bracing, guys, or other devices as required to accomplish erection and to provide safety and stability until work is in final position and approved.

G. Avoid overloading any part of the structure. Repair or replace any item damaged due to overloading.

H. 35 kV elbow termination enclosures located in damp or wet locations, shall be placed and equipped so as to prevent moisture or water from penetrating and accumulating within the enclosure. Minimum foundation pad height from the surrounding ground surface elevation shall be four inches.

I. Ensure pad mounted 35 kV elbow termination enclosure or stand is not in direct contact with the concrete foundation.

J. Apply waterproof, non-hardening sealing compound or grout between the foundation and the base perimeter of the 35 kV elbow termination enclosures enclosure (for the pad mounted option).

K. The minimum unobstructed horizontal clearance between 35 kV elbow termination enclosures enclosure (for the pad mounted option) and adjacent equipment and structures shall be 8 feet.

L. Verify the 35 kV elbow termination enclosures and associated materials are correctly installed in accordance with the approved installation manual and drawings. No cable bends allowed within 12 inches of connector assembly. Minimum 18 inches vertical distance between bottom of enclosure and ground.

M. Tighten electrical connectors and terminals according to manufacturer’s published torque-tightening values. If manufacturer’s torque values are not available, use those specified in UL 486 A & B.

N. Protect the 35 kV elbow termination enclosures and associated materials during field installation and field testing activities. Repair or replace items damaged.

O. Complete the installation and cleaning of 35 kV elbow termination enclosures, associated materials and conduits before starting wire or cable installation.

P. Route new 35 kV cables and conduits to the 35 kV elbow termination enclosure as indicated.

Q. Connect grounding cables from enclosure, elbow assembly, and cables to common grounding bar in the 35 kV elbow termination enclosure.

R. Clean 35 kV elbow termination enclosures per the manufacturer’s recommendations prior to installation verification and field testing.

3.05 FIELD TOUCH-UP

A. Remove paint splatters and other spots.

B. Clean and repaint damaged interior and exterior surface coatings of the 35 kV elbow termination enclosures with the same coating system using touch up paint provided by the manufacturers.

C. Painting shall follow the recommendations of the pain manufacturers. Provide the appearance of a new installation prior to Acceptance.

3.06 INSTALLATION VERIFICATION, FIELD FUNCTIONAL AND SYSTEM INTEGRATION TESTING

A. Refer to following Sections for requirements:

1. Section 34 21 80 Traction Power System Field Acceptance Testing

2. Section 34 22 23 Traction Power Cables

3.07 CLEANING

A. Refer to Section 01 74 14, Cleaning, for additional requirements.

3.08 CLOSEOUT PROCEDURES

A. Refer to Section 01 77 00, Closeout Procedures, and Section 01 78 39, Project Record Documents, for requirements.

END OF SECTION 34 21 19

SECTION 34 21 20

AC BUSWAYS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. General Requirements

B. Enclosure

C. Buses and Bus Connections

D. Fittings

E. AC Busway Rating

F. AC Busway Structural Supports

1.02 RELATED SECTIONS

A. Refer to the following Sections for requirements:

1. Section 01 33 00 Submittal Procedures
2. Section 01 33 23 Shop Drawings, Product Data, and Samples
3. Section 01 74 14 Cleaning
4. Section 01 77 00 Closeout Procedures
5. Section 01 78 23 Operation and Maintenance Data
6. Section 01 78 39 Project Record Documents
7. Section 01 79 00 Demonstration and Training
8. Section 05 12 00 Structural Steel Framing
9. Section 34 21 60 Grounding and Bonding for Traction Power
10. Section 34 21 01 General Requirements for the Traction Power System
11. Section 34 21 05 Prefabricated AC and DC Equipment Houses
12. Section 34 21 21 Transformer-Rectifier Units
13. Section 34 21 50 Common Materials and Methods for Traction Power
14. Section 34 21 70 Traction Power Facilities Installation Requirements

15. Section 34 21 80 Traction Power System Field Acceptance Testing

1.03 MEASUREMENT AND PAYMENT

A. Separate measurement and payment will not be made for work required under this Contract Specifications Section. All costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work.

1.04 REFERENCES

A. Activities shall be in accordance with the following codes, standards, and specifications except as provided herein. Where requirements conflict with requirements specified herein or elsewhere in the Contract the more restrictive requirements shall apply.

B. American National Standards Institute (ANSI):

1. IEEE C37.23 Standard for Metal-Enclosed Bus

C. National Electrical Manufacturers Association (NEMA):

1. NEMA BU1 Busways

D. Underwriters Laboratories (UL):

1. UL 857 Standard for Safety Busways

1.05 SUBMITTALS

A. Refer to the following Sections for additional requirements:

1. Section 01 33 00 Submittal Procedures
2. Section 01 33 23 Shop Drawings, Product Data, and Samples
3. Section 01 45 24 Testing Program Requirements
4. Section 01 78 23 Operation and Maintenance Data
5. Section 01 79 00 Demonstration and Training
6. Section 34 21 01 General Requirements for the Traction Power System

B. Submit the following documents for equipment and materials specified herein and provided under the Contract for the AC busways:

1. Refer to Section 34 21 01, General Requirements for the Traction Power System, Article 1.17C and Article 1.17D for traction power general and vendor deliverable requirements.

2. Product data and shop drawings for the AC busways and associated structural supports.

3. Electrical calculations approved by California-registered professional electrical engineer.

4. Seismic calculations for the structural supports approved by California-registered structural engineer.

5. Certificates from manufacturers verifying that equipment conforms to specified requirements.

6. Material safety data sheets.

7. Painting process details.

8. Factory acceptance test documentation (e.g. test plan and procedures, data sheets, reports).

9. Installation manual and drawings.

    a. Installation manual shall include:

        1) A table of contents that shall identify pages of the manual by revision and date.

        2) Installation practices and procedures that the Contractor plans to use to accomplish the installation of the AC busways and associated structural supports and shall be kept current at all times.

        3) A list of installation drawings by number, revision, title and approval status and a copy of each drawing reduced to B size (11 by 17 inches).

        4) Quality control procedures associated with the transportation and installation of the AC busways and associated structural supports.

        5) Installation verification procedures and data sheets.

        6) Staging and implementation plans.

10. Certification that exterior powder coating system for the AC busways is a two-step process that provides 5 mils minimum thick weather-resistant finish.

11. Installation verification and field functional test documentation (e.g. procedures, data sheets, reports) per Section 34 21 80, Traction Power System Field Acceptance Testing.

12. System integration test documentation (e.g. procedures, data sheets, reports) per Section 34 21 80, Traction Power System Field Acceptance Testing.

13. Spare Parts List.

14. Warranty Certification.

1.06 QUALITY CONTROL, QUALITY ASSURANCE AND SUPPLIER QUALIFICATIONS

A. Refer to Section 34 21 01, General Requirements for the Traction Power System, Article 1.07, and Section 34 21 70, Traction Power Facilities Installation Requirements, Article 1.06 for requirements.

1.07 DELIVERY, STORAGE AND HANDLING

A. Refer to Section 34 21 70, Traction Power Facilities Installation Requirements, Article 1.07 for requirements.

B. Equipment shall be weatherproofed for shipment. Connection openings shall be closed to prevent entrance of foreign material during shipment and storage.

C. Equipment shall be handled and stored in conformance with manufacturer's instructions. One copy of these instructions shall be included with the equipment at time of shipment.

1.08 GENERAL REQUIREMENTS FOR THE TRACTION POWER SYSTEM

A. Refer to Section 34 21 01, General Requirements for the Traction Power System, for requirements.

PART 2 – PRODUCTS

2.01 GENERAL

A. Aerial AC busways shall connect the outdoor rectifier transformers to the traction rectifiers installed inside the DC switchgear house, for operation as an integral unit.

B. AC busways and associated accessories shall be of the non-segregated type.

C. Each AC busway shall include an assembly of rigid copper conductors with associated connections, joints, insulators, bracing, and supports within a metal enclosure.

2.02 ENCLOSURE

A. AC busways shall be housed in enclosure with bolted flange connection for assembly at the rectifier transformer and traction rectifier throat. The busway enclosure shall be a rigid structure, fabricated from formed steel sheets of No. 11 gauge minimum thickness.

B. The outdoor portion of the AC busway enclosure shall be weatherproof.

C. The AC busway enclosure shall be provided with:

1. Removable gasketed covers for access to bolted bus connections and insulators, and access at the transformer connection for ease of maintenance and testing. Covers shall be secured with rust-resistant bolts to the frame of the AC busway.

2. Space heaters as specified in Article 2.20A of Section 34 21 50, Common Materials and Methods for Traction Power, and provisions for draining condensation.

3. Insulating joints at the interface with the traction rectifier, for electrical isolation from the high-resistance grounding system of the rectifier frame and structure.

4. Noncombustible, weatherproof seals at each location where the busway penetrates an outside wall. The seals shall be on both sides of the wall and shall accommodate 1/2 inch differential settlement between the foundations.

5. Removable covers for ease of installation and maintenance.

D. Finish

1. Enclosure finish shall be treated with a galvannealed coating and finish with a powder coat.

2. The galvannealing coating process shall be a two-step coating process with the following characteristics:

   a. Lower coating shall be 10 percent iron-zinc alloy deposited by the hot-dip process.

   b. Lower coating weight: 60 g/m2, minimum.

   c. Lower coating shall be 80 percent iron-zinc alloy electroplated deposited by the hot-dip process.

   d. Upper coating weight: 3 g/m2, minimum.

   e. Corrosion resistant capabilities: Maximum 1/8 inch creep corrosion when vertically scribed and exposed to five percent salt fog per ASTM B117 for 1500 hours.

3. The powder coating process shall be a two-step process with the following characteristics:

   a. Thickness: 5 mils, minimum.

   b. Color: Medium beige to match the color of the traction power substation houses provided.

   c. Weather, graffiti, and ultra-violet (UV) resistant.

d. Following busway assembly, areas exposed to the outside atmosphere that have been affected by cutting or welding shall be spot galvanized with a primer that forms a dry film no less than 90 percent pure zinc. Touch-up paint shall be applied to match the powder coat finish.

e. Following house assembly areas exposed to the outside atmosphere that have been affected by cutting or welding, shall be spot galvanized with a primer that forms a dry film no less than 90 percent pure zinc. Touch-up paint shall be applied to match the powder coat finish.

2.03 BUSES AND BUS CONNECTIONS

A. Buses and bus connections shall be as specified in Article 2.01 of Section 34 21 50, Common Materials and Methods for Traction Power.

B. The length of each bus conductor including fittings shall be insulated individually within each busway. Insulation and insulators shall be NEMA Class B and nonhygroscopic.

C. Provide visible grounding provisions for connection to main substation grounding system.

2.04 FITTINGS

A. AC busway assemblies shall be complete with connection flanges, seals, taps, elbows, insulated housing sections, offsets, splicing plates, terminal connectors, and associated accessories.

B. Expansion joints shall be provided where required for normal operation of the equipment.

C. AC busways shall be designed to minimize induced magnetic heating and induced circulating currents in the metallic enclosure of the busway, adjacent enclosures, and supporting structures.

D. Each AC busway shall be provided with support fittings for trapeze hangers.

2.05 AC BUSWAY RATING

A. AC busways shall be rated for 1,200 V AC nominal, with a continuous current rating not less than 160 percent of the continuous full-load current rating of the associated transformer-rectifier unit.

B. The AC busway shall be capable of withstanding stresses due to a phase bolted short-circuit at the rectifier terminals, with a fault level of 1,000 MVA symmetrical on the 34.5 kV side of the rectifier transformer.

2.06 AC BUSWAY STRUCTURAL SUPPORTS

A. AC busway enclosures shall be supported by the transformer throat connection, the trapeze hangers inside the DC switchgear house and intermediate supports as required. If made of ferrous metal, busway enclosure components and supports shall be hot-dip galvanized. Nuts, bolts, and washers shall be cadmium plated.

B. The structural supports shall include ungalvanized grounding lug plates welded to the tubular steel members to permit connection of bonding jumpers and/or ground connections. Lug plate design shall include holes to permit attachment of 2 hole compression lugs (associated with 250 kcmil bare copper ground pigtail).

C. Refer to Section 05 12 00, Structural Steel Framing, for additional requirements.

2.07 FACTORY INSTALLATION

A. Fabricate AC busways with equipment, devices, accessories, and appurtenances in place for a fully functioning and operable AC busway.

2.08 FACTORY ACCEPTANCE TESTING

A. Refer to Section 01 45 24, Testing Program Requirements, for additional requirements.

B. Prior to scheduling factory acceptance test to be witnessed by the Engineer, ensure AC busways are fabricated and assembled per the approved equipment vendor design.

C. Design tests shall be performed in accordance with IEEE C37.23 and UL 857 on one unit for the metal-enclosed bus, including the following:

1. Dielectric tests:
    a. Power frequency withstand voltage.
    b. Impulse withstand voltage.
2. Temperature rise test.
3. Momentary current test.
4. A test to verify that the busway enclosure is watertight.

D. Power frequency voltage withstand tests shall be performed on AC busways in accordance with the production tests specified in UL 857 for metal-enclosed bus.

PART 3 – EXECUTION

3.01 FOUNDATION COORDINATION

A. Examine foundations, anchor bolts, and exposed grounding embed conditions for compliance with the approved construction design and vendor's requirements prior to placement of the AC busway structural steel supports.

B. Note items may infringe on the necessary clearances and other non-compliances. Promptly bring noted issues to the attention of the Engineer for direction and approval before proceeding.

C. Provide corrective actions, as required, at no additional cost to the District.

3.02 FIELD INSTALLATION

A. Reference Section 34 21 21, Transformer-Rectifier Units, for requirements relating to the installation of the transformer rectifier units.

B. Where the AC busway structural support is located within the containment area (of the rectifier transformer) the following requirements apply:

1. The design of the containment area shall include a concrete plinth upon which the supporting structure shall be installed.

2. No part of the AC busway supporting structure shall be below the highest point in the containment area.

C. Install the AC busway supports on the foundation secure, level (with stainless steel shims if required), plumb, and in true alignment with related adjoining work. Secure the AC busway structural supports to the foundations in accordance with equipment vendor's recommendations and the approved seismic design.

D. Control erection tolerance requirements so as not to impair the strength, safety, serviceability, or appearance.

E. The portion of the AC busway enclosure between the insulating joint at the rectifier interface and the rectifier transformer shall be connected to the underground ground grid. Install grounding connections to the underground ground grid system and bonding conductors between AC busway components and structural steel supports per the approved construction and equipment vendor designs, and Section 34 21 60, Grounding and Bonding for Traction Power.

F. Apply waterproof, non-hardening sealing compound/grout between the foundation and the base perimeter of the AC busway structural supports.

G. The physical arrangement shall permit installation and removal of throat or bus connections without moving the rectifier or rectifier transformer.

H. Unless otherwise approved by the District, the AC busway's vibration bellows and stiffener collars shall be installed adjacent to the rectifier transformer end.

I. The bottom or underside surface of the AC busways shall be installed not lower than 84 inches above finished floor.

J. Provide visible bus duct ground connection direct to primary substation ground.

K. The minimum unobstructed horizontal clearance between AC busway structural supports and adjacent equipment and structures shall be 36 inches.

L. Protect the AC busways and associated structural supports during field installation and field testing activities.

M. Refer to Section 34 21 70, Traction Power Facilities Installation Requirements, for additional requirements.

3.03 FIELD TOUCH-UP

A. Remove paint splatters and other spots.

B. Clean and repaint damaged interior and exterior surface coatings of the AC busways and associated structural supports with the same coating system used in the factory, using touch up paint provided by the manufacturers.

C. Painting shall follow closely the recommendations of the paint manufacturers. Provide the appearance of a new installation prior to Acceptance.

3.04 INSTALLATION VERIFICATION, FIELD FUNCTIONAL AND SYSTEM INTEGRATION TESTING

A. Refer to Section 34 21 80, Traction Power System Field Acceptance Testing, for requirements.

END OF SECTION 34 21 20

SECTION 34 21 21

TRANSFORMER-RECTIFIER UNITS — OIL FILLED TRANSFORMER, UNCONTROLLABLE RECTIFIER

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. General

B. Overload Requirements

C. Ratings

D. Rectifier Transformers

E. Rectifiers

F. Factory Testing

G. System Factory Functional Testing

H. Field Acceptance Testing

1.02 RELATED SECTIONS

A. Section 01 33 00 Submittal Procedures

B. Section 01 33 23 Shop Drawings, Product Data, and Samples

C. Section 01 78 23 Operations and Maintenance Data

D. Section 01 45 24 Testing Program Requirements

E. Section 34 21 01 General Requirements for the Traction Power System

F. Section 34 21 75 Traction Power Facility System Factory Functional Testing

G. Section 34 21 80 Traction Power System Field Acceptance Testing

1.03 MEASUREMENT AND PAYMENT

A. Measurement: Oil filled transformers and uncontrolled rectifier units will be measured for payment per individual unit of each type that is tested and furnished in accordance with the Contract Documents.

B. Payment: Oil filled transformers and uncontrolled rectifier units will be paid for at the Contract unit price per each individual unit of each type as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. American National Standards Institute (ANSI):

1. ANSI C37.45	Standard Specifications for High-Voltage Distribution Class Enclosed Single-Pole Air Switches with Rated Voltages from 1 kV through 8.3 kV

B. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE C37.20.1	Standard for Metal-Enclosed Low Voltage (1000 VAC and below, 3200 VDC and below) Power Circuit Breaker Switchgear
2. IEEE C37.20.2	Standard for Metal-clad Switchgear
3. IEEE C37.41	Standard Design Tests for High Voltage (>1000V) Fuses and Accessories
4. IEEE C57.12.00	Standard for General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
5. IEEE C57.12.10	Standard Requirements for Liquid-Immersed Power Transformers
6. IEEE C57.12.70	Standard Terminal Markings and Connections for Distribution and Power Transformers
7. IEEE C57.12.90	Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers
8. IEEE C57.12.91	Standard Test Code for Dry-Type Distribution and Power Transformers
9. IEEE C57.13	Standard Requirements for Instrument Transformers
10. IEEE C57.18.10	Standard Practices and Requirements for Semiconductor Power Rectifier Transformers
11. IEEE C57.113	Recommended Practice for Partial Discharge Measurement in Liquid-Filled Power Transformers and Shunt Reactors
12. IEEE 1653.1	Standard for Traction Power Rectifier Transformers for Substation Applications up to 1500 VDC Nominal Output
13. IEEE 1653.2	Standard for Uncontrolled Traction Power Rectifiers for Substation Applications up to 1500 VDC Nominal Output

C. National Electrical Contractors Association (NECA):

1. NEIS National Electrical Installation Standards

D. National Electrical Manufacturers' Association (NEMA):

1. NEMA ICS 4 Application Guideline for Terminal Blocks

2. NEMA TR 1 Transformers, Step Voltage Regulators and Reactors

E. National Fire Protection Association (NFPA):

1. NFPA 70 National Electrical Code (NEC)

F. JEDEC Solid State Technology Association:

1. JESD282B.01 Silicon Rectifier Diodes

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures; and Section 01 33 23, Shop Drawings, Product Data, and Samples for submittal requirements and procedures.

B. Product Data: Submit product data to include the following:

1. Physical arrangement and assembly drawings of rectifier transformer and traction rectifier

2. Wiring connections

3. Schematic drawings

4. Brief description of devices and their functions and protective relay settings

5. Equipment nameplate

6. Transformer oil data including toxicity and liquid flash point temperature

7. Transformer data including rated kVA, frequency, primary and secondary voltages, percent taps, polarity, impedance and certification of transformer performance efficiency at indicated loads, percentage regulation at 100 percent and 80 percent power factor, no-load and full load losses in watts, percent impedance at 75 degrees Celsius, hot-spot and average temperature rise above 40 degrees Celsius ambient temperature, sound level in decibels, and standard published data

8. Product data for the traction rectifier including diodes, fuses, heat sinks, over-voltage protection devices, fuse monitoring, and door interlocks

C. Design calculations for the transformer-rectifier unit, including extended voltage regulation curve from light transition load to short-circuit condition, no-load voltage, power factor as function of loading, efficiency as function of loading, harmonics on the DC and AC side, and sizing of dummy (base) resistor.

D. Test plan and procedures for factory testing of the rectifier transformer.

E. Test report for factory testing of the rectifier transformer.

F. Test plan and procedures for factory testing of the traction rectifier.

G. Test report for factory testing of the traction rectifier.

H. Test plan and procedures for factory testing of the transformer-rectifier unit.

I. Test report for factory testing of the transformer-rectifier unit.

J. Test plan and procedures for field testing of the rectifier transformer.

K. Test report for field testing of the rectifier transformer.

L. Test plan and procedures for field testing of the traction rectifier.

M. Test report for field testing of the traction rectifier.

N. Test plan and procedures for field testing of the transformer-rectifier unit.

O. Test report for field testing of the transformer-rectifier unit.

P. Installation Manual: Submit manufacturer recommended procedures for installation of the rectifier transformer.

Q. Operations and Maintenance Manuals: Provide the following Operations and Maintenance Manuals in accordance with Contract Specifications Section 01 78 23, Operations and Maintenance Data. Standard off the shelf manuals shall be submitted as pre-final manuals.

1. Manual outlines
2. Complete draft
3. Pre-final manuals
4. Final approved manuals
5. Manual revisions
6. Recommended (annual) schedule periodic tests

R. Design calculations for the rectifier transformer, including power rating, windings turn ratio, impedance, commutating reactance, no-load losses, full-load losses, and seismic calculations.

S. Design calculations for the traction rectifier, including determination of the number of diodes per rectifier leg, continuous current and short-term overload capability, fuse ratings, and transient voltage suppression devices.

1.06 QUALITY ASSURANCE AND SUPPLIER QUALIFICATIONS

A. Electrical components, devices, and accessories shall be listed and labeled in conformance with NFPA 70, Article 100. Electrical components, devices, and accessories and their installation shall comply with NECA's National Electrical Installation Standards (NEIS).

B. Transformers and rectifiers shall be proven standard products, or equivalent to the standard products of manufacturers engaged in the production of such equipment for at least the past five years.

C. The manufacturer of the rectifier transformers shall have a minimum of five years manufacturing experience with three winding, liquid filled power transformers, utilizing IEEE 1653.2 Circuit 31 configurations.

D. The engineer responsible for the design of the rectifier transformers and rectifier must have a minimum of 5 years of project-proven experience in the design of 3-winding rectifier transformers.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Delivery, loading/unloading, handling, storage and protection of transformer shall be in accordance with manufacturer's guidelines.

B. Equipment shall be packaged for arrival at the site undamaged by handling and weather.

1. Temporary braces, guides, skids, crates and other shipping devices necessary for transporting and temporary storage of the equipment shall be furnished.

2. Equipment shall be protected against corrosion, dampness, damage due to vibration, and any other damage during transportation and handling. Opening to the external environment shall be sealed before shipping. Products shall be packed in weatherproof containers for storage outdoors.

C. Impact Recorder: Impact recorder is required for shipping to and from test locations and from the supplier's facility to the District. A report shall be submitted to the Engineer for each travel segment. Submit recordings for each travel segment within 24 hours of the completion of each trip.

1.08 WARRANTY

Warranty for the rectifier transformers, traction rectifiers, and associated system components shall be provided and signed by the manufacturer and installer agreeing to correct system deficiencies and replace components that fail in materials or workmanship. The warranty shall be for the period between installation and the start of revenue service, five years from the date of system in revenue service for rectifier transformers and components, and two years from the date of system in revenue service of traction rectifiers and components.

1.09 GENERAL REQUIREMENTS

Refer to Contract Specifications Section 34 21 01 for contract general requirements.

PART 2 – PRODUCTS

2.01 GENERAL

A. Manufacturer shall coordinate the requirements of associated substation equipment to provide a 1000 VDC traction power supply.

B. Transformer windings, rectifier buses, and interconnecting AC buses shall be made of copper conductors.

C. The transformer-rectifier units shall be designed and fabricated in accordance with the latest revision of the applicable ANSI, IEEE, and NEMA Standards as listed in Section 1.04.

D. Each unit shall consist of a rectifier transformer and a traction rectifier with necessary hardware, wiring, and devices as indicated, and as required for a complete and operating installation.

E. The rectifier transformer will receive 34.5 kV, 3-phase, 60 Hz, three-wire power from 34.5 kV switchgear and shall transform the high voltage to a low AC voltage rated as required by the traction rectifier.

F. The rectifier transformer and traction rectifier shall be designed for interconnection by aerial AC busway, as indicated. Connections between the rectifier and the DC switchgear may be by either DC cables or bus, depending on the rectifier and switchgear design.

2.02 OVERLOAD REQUIREMENTS

A. The transformer-rectifier unit shall be rated for extra heavy-duty traction load. The unit shall be able to operate at the following overload cycle, beginning from operation at nominal load and stabilized temperature:

1. 150 percent of rated current for two hours, with superimposed five periods of one minute duration at 300 percent of rated current each, equally spaced throughout the two-hour period, and

2. 450 percent of rated current for 15 seconds at the end of the two-hour period.

B. The transformer-rectifier unit shall withstand two overload periods as specified above on a daily basis, spaced 8 hours apart, each preceded and followed by the continuous 100 percent load level.

C. The transformer-rectifier units shall be designed to meet the above daily duty cycle without damage to any parts or the insulation for a period of 25 years.

D. Current unbalance caused by loss of one diode per phase shall be taken into consideration in the design, and shall not reduce the specified overload capability of the rectifier.

2.03 RATINGS

A. Unit Capacity

1. The KW rating of the transformer-rectifier units shall be as indicated. The units shall be designed to deliver the rated KW output at rated terminal voltage.

2. The units shall withstand continuous operation at 110 percent rated voltage without exceeding the equipment temperature limitations.

B. Efficiency: The overall efficiency of the transformer-rectifier shall be greater than 97.5 percent at its continuous rating. No-load core losses shall not exceed 0.25 percent of the rated unit capacity.

C. Power Factor: The displacement power factor of the transformer-rectifier units shall be 0.95 or greater from 25 percent to full load with rated AC input voltage.

D. Voltage Regulation: The transformer-rectifier units' initial regulation shall be six percent. The regulation shall be linear from light transition (one percent) load to at least 300 percent of full load. Manufacturing tolerance shall not exceed 10 percent of the specified regulation value. The voltage at the rectifier output at no-load shall not exceed 1350 VDC at rated primary voltage of 34.5 kV. The light transition load voltage shall be approximately 1,060 volts DC at the rated primary voltage of 34.5 kV, while the full-load (nominal) voltage shall be 1000 VDC, with plus-or-minus six V maximum deviation allowed for manufacturing tolerance.

E. Short-Circuit

1. Each transformer shall be designed to withstand a full short-circuit at the low-voltage terminals at rated voltage on the high-voltage terminals for one second, in accordance with IEEE C57.12.00 and C57.12.10.

2. All parts of the rectifier unit, including the terminal connections and buswork, shall be designed to withstand a bolted fault on the DC positive bus, without damage, for the time period required for the backup protection to operate and open the AC circuit breaker.

3. The transformer shall be designed to withstand the short-circuit power available from the 34.5 kV subtransmission lines at the switching stations which is expected to be up to 500 MVA.

4. The secondary windings of the rectifier transformer shall be coupled magnetically, so that at a given fault level of 500 MVA at 34.5 kV, the sustained short circuit current on the rectifier bus for a bolted fault does not exceed nine times the full load current.

F. Additional Rating Requirements: See Section 2.04 for rectifier transformer ratings.

G. Voltage Transients

1. A plan of the design techniques, construction methods, and equipment employed to protect against transient surge voltages shall be submitted for approval.

2. If fuses are used in surge suppression networks, they shall be monitored by visual indicators, and shall be equipped with devices capable of being monitored both locally and remotely.

3. A surge protection network at the input terminals shall protect each rectifier unit from damage due to switching voltage transients up to 2.5 times normal voltages in the 34.5 kV AC system. Failure of the surge protection network shall be annunciated both locally and remotely as indicated.

4. A static voltage surge suppressor rated to withstand expected voltage transients, shall protect each rectifier from lightning surges transmitted along DC contact rails, and from voltage transients on the DC system due to breaker switching. A counter shall be provided for the surge suppressor. Failure of the surge suppressor shall be annunciated both locally and remotely as indicated.

5. The surge suppressor shall absorb surge energy of 50 kilojoules minimum with bus potential below 2600 volts at instantaneous current of 4000 amperes.

6. The peak value of contact rail transient voltages are expected to be 3000 volts for 8 milliseconds or 6000 volts for 50 microseconds with rise time of 1.2 microseconds.

H. Noise Levels

1. Equipment design, enclosures with acoustic mitigation capability, and other measures, as appropriate, shall be employed to achieve compliance with the specified audible noise level criteria.

2. The noise level measured at a distance of 15 feet from the rectifier transformer with the transformer operating at 100 percent load and nominal voltage shall not exceed 55 dBA.

3. The noise level measured at a distance of five feet from the rectifier with the rectifier operating at 100 percent load and nominal voltage shall not exceed 60 dBA.

4. Submit proof in the form of calculations or empirical data that the rectifier transformer meets the noise level requirements.

2.04 RECTIFIER TRANSFORMERS

A. General

1. Rectifier transformer shall be self-cooled, oil-immersed, 60 Hertz transformers suitable for outdoor service, designed for extra heavy-duty traction service as specified, conforming to the applicable requirements of IEEE C57.12.00, IEEE C57.12.10, IEEE C57.12.90, IEEE C57.18.10, IEEE 1653.1, and NEMA TR-1. The rectifier transformers shall be suitable for operation on 34.5 kV line-to-line, effectively grounded neutral system.

B. Ratings: Rectifier transformers shall have the following minimum ratings:

1. Capacity: MVA rating as required to meet the specified ratings and performance requirements for the transformer-rectifier units.

2. Primary Winding Nominal Voltage: 34.5 kV

3. Secondary Winding Nominal Voltage: As required to meet the specified performance requirements for the transformer-rectifier units.

4. Frequency: 60 Hz

5. No. of Phases: Primary shall be three. Secondary shall be six.

6. Cooling Class: KNAN

7. Average Winding Temperature Rise above 50 degrees Celsius Ambient after Stabilized Continuous Operation at 100 percent load: 55 degrees Celsius maximum

8. Hottest-Spot Temperature Rise above 50 degrees Celsius Ambient after Stabilized Continuous Operation at 100 Percent Load: 65 degrees Celsius maximum

9. Basic Insulation Level (BIL) Peak:

    a. Primary Winding: 150 kV minimum

    b. Secondary Windings: 30 kV minimum

10. Connections:

    a. Primary Winding: Delta

    b. Secondary Windings: Delta/Wye for the two six-pulse double-way rectifiers in accordance with IEEE 1653.2, circuit number 31.

11. Bushings: Rated voltage and BIL peak ratings not less than winding ratings.

C. Taps and Tap Changer:

1. Taps: The high voltage winding shall have four no-load, full-capacity taps: two 2.5 percent above, and two 2.5 percent below the rated line-to-line voltage of 34.5 kV.

2. Changer: An off-load tap changer shall be provided with an operating handle mounted on the exterior of the tank. A position indicator and provision for padlocking shall be provided in an accessible location.

D. Alarm and Trip Devices: Transformer shall be equipped with the following:

1. Sudden pressure relay, device 263/SP with alarm and trip contacts.

    a. The sudden pressure device seal-in relay shall be equipped with an undervoltage relay with a closed auxiliary contact that shall activate the Device 286 lockout relay if control power is lost on the device 263/SP seal in relay.

2. Pressure relief device 263PR

3. Liquid level gauge, device 263/QL with two low-level alarm contacts. One low level alarm and low low-level trip.

4. Pressure/vacuum gauge.

5. Two stage top oil temperature indicator, device 226/QT with alarm and trip contacts with adjustable temperature set points.

6. Hot-spot winding temperature indicator, device 249/WT, minimum two stages, with alarm and trip contacts with adjustable temperature set points.

7. Alarm and trip annunciations due to activation of any of the above protective devices including control power alarms shall be communicated via an I/O module located in the control cabinet through fiber optic cable to the station CO2 panel.

8. The top of the transformer control panel shall not be more than 6.5 feet above the finish grade level where personnel accessing the control cabinet stand; the bottom of the transformer control panel shall be less than 3.5 feet from finish grade above the finish grade level where personnel accessing the control cabinet stand.

E. Heaters

1. The main transformer control cabinet shall have thermostatically controlled anti-condensation heaters.

2. Heater capacity shall be equally divided into two and located at the sides of the cabinet to maintain adequate clearances from entering cables.

F. Construction Requirements

1. The rectifier transformers shall be designed for high voltage enclosed cable connections on the primary side and throat connection accommodating aerial busway to the rectifier. The rectifier transformers shall be provided with incoming line section for terminating the 35 kV power cables entering from below as indicated. The section shall be large enough to accommodate built –up tape stress cones.

2. The incoming 34.5 kV incoming line section and the control cabinet shall be NEMA 4X with doors located on either side of the transformer tank and within reach of person standing on the transformer base level. Doors shall be hinged and provided with stops to hold the doors in open position. Door shall be provided with handle and three-point lockable latch.

3. The incoming 34.5 kV incoming line section shall be provided compression lugs for terminating the 35 kV, # 2/0 AWG power cables entering from below as indicated.

4. Base construction shall firmly secure the core to prevent relative motion of the core during shipment, handling, and seismic shock.

5. Transformers shall be provided with lifting lugs located at the top of the unit in such a manner to allow the unit to be lifted by a boom-type crane or hoist without tilting of the unit.

6. The transformer shall be designed for mounting on a concrete pad.

7. The transformer tank shall be a sealed tank liquid preservation system.

8. The transformer shall include the following:

   a. Top filter press connection and sampling device

   b. Tank bottom drain valve and sampling device

   c. Gasketed, bolted roof-mounted inspection covers to gain access to internal devices or connections

d. Nameplate with connection diagram. As tested information stainless steel nameplate shall be provided

e. Warning signs as required

f. Weatherproof, oversize connection box with provision for extension throat and access to end or side, removable for termination of low-voltage cables

g. Primary and secondary bushings shall be side mounted

9. Coating:

a. Color:

1) Powder coat: Medium beige, Sherwin Williams number PLT6-1S4 or equal.

2) Wet paint color: Medium beige, Sherwin Williams number F63RXN28022-4337 POLANE S or equal for touch up

3) Aerosol can: Medium beige, Sherwin Williams number J22XXN28029-4337 or equal for touch up

b. Weather, graffiti, and ultra-violet (UV) resistant

c. Radiators may be painted or galvanized, unpainted per manufacturer's recommendations.

10. Transformer Tank

a. The tank shall be mounted on a structural steel base that is adequate to provide support for the completely assembled transformer filled with oil and to prevent distortion during operation or relocation. Internal bracing shall not interfere with oil drainage. The structural steel base shall consist of at least two members parallel to the transformer major axis and at least two members parallel to the minor axis. The undersides of all members shall be in the same plane. The spacing of the base member shall be such as to permit the completely assembled transformer with or without oil to be safely tilted 15 degrees.

b. Transformers shall be of the sealed tank, welded steel plate and cover construction, outdoor type, liquid tight, with bolted and gasketed manhole(s) on top of tank. They shall be mounted on steel skid base, suitable for skidding in any direction. Use care to avoid tank or component distortion during welding operations. Assembled transformer base shall be sufficiently flat to be installed on a flat concrete foundation without supplemental shims. They shall be adequately designed and braced to allow full vacuum filling and vacuum drying operations in the field.

c. Provide jacking lugs and pulling eyes for lifting or moving along either axis when completely assembled and oil-filled. Lifting lugs are to be mounted near the top of the tank. Jacking lugs shall be installed with suitable clearance to the bottom of the base plate.

d. Provide two NEMA two-hole silver-plated copper ground pads at diagonal opposite corners of transformer tank near base, with two-bolt terminal connectors for 250 kcmil copper conductors.

e. Maintain positive pressure continually to prevent ingress of moisture during shipping.

f. Provide an adequately braced domed or sloped top on major surfaces. Design tank and fittings to prevent water puddling on surfaces or in cavities.

g. Provide raised flanges with thru-bolts for removable cover penetrations, including bushings, manhole/handhole covers, and removable equipment. Welded studs are not acceptable.

h. Gasketed joints shall have machined surfaces on both sides and shall be provided with gasket retainers and metal-to-metal stops to assure even and effective pressure and to avoid over-stressing the gasket. Gaskets shall maintain oil-tight joints under service and fault conditions.

11. Core

a. Each core shall be fabricated from non-aging, cold-rolled, grain-oriented, stress-free, thin silicon steel laminations, with permeability and hysteresis loss characteristics necessary to satisfy design and performance requirements.

b. Provide each sheet with an insulated surface treatment that is impervious to hot transformer oil. Anneal properly with smooth surfaces at edges.

c. Core shall be rigidly clamped and blocked to prevent deteriorating vibrations, interference with oil circulation, objectionable noise conditions, and short circuit and shipment distortions.

d. Provide a core ground lead connected to an external bushing for each core. Provide a flexible ground strap to connect the terminal of the bushing to the transformer tank, thereby grounding the transformer core. Provide a suitable cover or deflector to protect the core ground bushing from damage from falling objects. Provide an engraved nameplate clearly indicating the function of the bushing. Provide a separate core ground bushing and ground strap for each separate core.

e. Serial number shall be stamped on core or core clamp in conspicuous place and shall be visible without the necessity for untanking or otherwise removing enclosure.

f. Provide means for properly handling core assembly when untanked.

12. Windings

a. The windings shall be of copper and have insulation of high dielectric and mechanical strength and shall be arranged to permit free circulation of oil. Proper internal barriers shall be provided. Additional insulation shall be provided on end coils to protect against line disturbances.

b. The coils shall be fabricated and braced to provide for expansion and contraction due to temperature changes and to avoid abrasion of insulation. The coils shall be braced to prevent distortion due to any abnormal operating conditions, and designed to withstand short circuit conditions in accordance with IEEE C57.12.90.

c. Each lead for connection to tap changers, bushings, etc. shall be permanently identified.

13. Instrument Transformers

a. Instrument transformers shall conform to IEEE C57.13. The current transformers (CTs) shall comply with the IEEE C57.13 relaying and metering accuracy standards, and shall have C200 accuracy class or better, under the burdens imposed by the connected services.

b. Instrument transformers shall be insulated for 1.0 kV voltage class, and shall have basic impulse insulation (BIL) level of 45 kV full-wave.

c. Current Transformers

1) The CTs shall be dry type, of molded rubber or epoxy construction, toroidal, bushing, or wound-type.

2) Ratio and phase-angle characteristics of CTs shall be suitable for the relaying as indicated.

3) CTs shall be installed in a manner such that they are easily accessible for inspection and maintenance.

4) Each CT per phase shall be rated as indicated.

5) CTs and their secondary wiring shall be protected from induced voltages by metallic shielding. Secondary wiring shall utilize No. 10 AWG copper wire, and shall be run to readily identifiable terminal blocks in the transformer control cabinet. The terminal blocks for the CTs shall be suitable for ring type wire connections, shall have covers, and shall feature integral shorting bars for the CT leads.

6) CTs shall be capable of withstanding thermal, magnetic, and mechanical stresses from the flow of current equal to the interrupting and momentary ratings.

14. Radiators

a. Radiators shall be detachable. The transformer cooling radiators shall be equipped with shut-off valves top and bottom and shall be bolted to the main tank to facilitate removal from the transformer main tank. The transformer shall be shipped with the radiators on at least one side removed to allow for the use of a standard size trailer, if necessary. The oil required to fill the removed radiators shall be shipped with the transformer or be provided by a local supplier.

b. Shutoff valves shall be equipped with a valve position indicator to indicate “valve open” or “valve closed”. The valves shall be lockable in the open and closed position. Steel blanking plates for openings shall be supplied.

c. Each radiator shall have a solid hex steel plug provided at the top and ball type drain valves at the bottom for drainage.

d. Each removable radiator shall be equipped with one lifting lug on top and one lifting lug on the bottom.

e. The design and construction of the radiators shall be such as to eliminate pockets where moisture can accumulate or which can prevent application of a continuous film of paint. Radiators shall be either hot dipped galvanized or painted in a fashion which ensures complete coverage of radiator surfaces. The radiators shall be provided with adequate bracing to prevent leakage from vibration.

f. Radiators are to have the same vacuum capability as the main tank.

15. Transformer Oil

a. The transformer shall be provided with enough transformer oil for filling its tank and radiators to the proper level.

b. Transformer oil shall be biodegradable natural ester-based insulating fluid that provides for a low- vapor-pressure, low-viscosity, high-flash-point, stable insulating oil.

c. Supplier shall certify, 60 Days before delivery that oil used in rectifier transformers contain less than one ppm PCB at time of manufacture.

d. The oil shall be Environtemp FR3 or approved equivalent.

e. Containment drain valve shall incorporate hardware that will allow for water to flow out of the containment pit at a flow rate equivalent or greater than a 1-1/2" diameter pipe. The same hardware shall cease all liquid flow from the containment pit if transformer oil is detected. The hardware shall detect oil using a passive system that does not require control power.

G. Special Tools

1. Special tools required for installation and maintenance of the equipment shall be identified by the manufacturer at time of bid.

H. Marking

1. Every transformer shall be provided with a rating plate showing the information required by the applicable IEEE Standard.

2. The rating plate shall indicate the type of conductor used for high voltage and low voltage windings (e.g. copper).

3. The rating plate shall indicate the transformer is constructed for Extra-Heavy Traction Duty as defined in IEEE C57.18.10.

4. The transformer shall be provided with nameplate that reads:

   “Transformer oil contains less than one parts per million polychlorinated biphenyls at time of shipment.” and “Refill with Envirotemp FR3 or approved equal.”

2.05 RECTIFIERS

A. General

1. Each rectifier bridge or section shall be a complete self-contained unit consisting of silicon diodes, heat sinks, protective fuses, natural ventilation system, copper buses and bus connections, enclosure with doors, hardware, gaskets, and other necessary accessories and devices.

2. The rectifier shall be the indoor type, with natural convection-cooling, and shall be designed to operate at 50 degrees Celsius ambient temperature.

3. The rectifier shall consist of two six-pulse, delta-wye, double-way circuits each having six legs of diode devices connected to the transformer delta wye secondary windings, per IEEE 1653.2 circuit No. 31.

4. An interphase transformer shall be provided between the direct outputs of the two six-pulse sections to absorb the instantaneous direct voltage differences. To achieve the lowest practical noise level, the core of the interphase transformers shall be designed to minimize the magnetostriction. Magnetostriction is the phenomenon of elastic deformation that accompanies magnetization. Noise damping treatment may be accepted in reducing the noise level by canceling some of the noise frequencies of the interphase transformer. However, the supplier shall submit calculations showing that any noise treatment allows rectifier ventilation that meets the specifications. Submit calculations showing that the noise level expected for the transformer under full load or maximum excitation meets the specified noise level limits for the transformer-rectifier unit per Article 2.03H herein. The calculations shall demonstrate adequate magnetic core material is used to accept expected IEEE 1653.2, extra heavy-duty rectifier loading with a noise level that meets the specifications. The calculations shall be signed by a California-registered professional engineer specialized in noise suppression field.

5. Materials shall be chosen to preclude the possibility of corrosive or galvanic action between dissimilar metals. Compatible materials shall be used for diode cases, studs, and heat sinks.

6. The rectifier enclosures shall be designed for high-resistance type enclosure-to-ground protective relaying.

B. Rectifier Enclosures

1. Panels comprising the rectifier enclosure including doors shall be constructed of sheet steel, not less than No. 11 gauge, and mounted on rigid, self-supporting structural steel framework.

2. Insulation shall be provided between the rectifier (including the DC main breaker cubicle) and the DC feeder breaker switchgear, and between the rectifier and the negative return cabinet. Adequate electrical insulation shall be provided between the rectifier enclosure and the AC busway from the rectifier transformer, such that a person cannot simultaneously touch the rectifier enclosure and any adjacent ground structure.

3. Louvered or mesh openings shall provide ventilation and air-cooling of the components by natural convection.

4. Ventilation intake openings shall be located not less than six inches above the floor.

5. Heat transfer surfaces and ducts shall be designed with smooth surfaces that minimize accumulation of dust and other contaminants.

6. Convenient access, including doors on both front and rear sides, shall be provided for normal maintenance and inspection of the rectifier.

7. Each enclosure door shall be equipped with:

   a. A mechanical latch to hold the door closed; and

   b. Door stops to hold door open for inspection of rectifier components.

8. Openings and mounting holes for front mounted indicating and control devices shall be cut out, drilled, or punched without marring or distorting the exposed finished surfaces of the control cubicles.

9. Rectifier enclosure shall be furnished with viewing windows so that blown-fuse indicators and the position of the negative disconnect switch can be seen from the outside, without opening the rectifier doors.

10. Separate compartments shall be provided to isolate control and auxiliary circuits and functions from the 1000 VDC buses and diodes.

11. Readings, controls, and observations shall be made without exposure to live parts. Internal lights with an external switch shall be included. Lighting fixtures shall be provided with guards.

12. Components installed in the rectifier shall be capable of withstanding 4600 VDC for one minute, applied between completely assembled rectifier and ground, with control circuits connected and energized or grounded, except that ground connection to the 164A/164G relay shall be disconnected and its contact set in the OPERATE (tripped) condition.

13. Provide rectifier unit with provisions to establish rectifier electrical clearance such that potentials inside the rectifier enclosure are connected together with conductors capable of withstanding a fault if the rectifier unit is inadvertently energized during at least 0.5 seconds for protection devices to clear the fault. AC incoming power supply, DC positive, DC negative, and the rectifier frame must be connected together to provide adequate and safe physical access for maintenance of the rectifier unit by maintenance personnel.

14. The enclosure shall be connected to the high resistance ground relay (Device 164A/164G) in the associated DC switchgear main breaker cubicle.

15. Devices mounted within rectifier enclosures that use 125 VDC control power from an external power source, and where no means is used to electrically isolate the circuit, shall be mounted on glastic type insulating material to electrically isolate the device from the structure.

C. Diodes

1. Diodes shall be rated and tested in accordance with JESD282B.01. Parallel strings of diodes shall be geometrically similar and as symmetrical as practicable to balance the normal and surge electrical characteristics of each string.

2. In addition to the parallel strings necessary to handle loads, as specified, additional capacity shall be provided so that, with one diode per phase leg out of service, each current path will still handle specified loads and maximum short circuit current.

3. Each diode shall be able to withstand, at its maximum operating temperature, voltages 2.5 times higher than the no-load AC bus voltage of the rectifier, without a permanent change in diode characteristics.

4. The maximum current unbalance between parallel strings in each phase and between phases shall be such that removal of any one diode per phase does not impact the required thermal capacity or short-circuit withstand capability of the rectifier.

5. Each parallel diode string shall be protected against internal short circuits by a current-limiting, fast-acting fuse equipped with a microswitch for local and remote status indications, and visible blown-fuse indicator.

6. Diodes shall have uniform voltage division within plus or minus ten percent across each diode.

7. Each parallel diode string shall be protected by a current-limiting fuse equipped with an indicator. The fuses shall be sized to withstand any external DC fault or loading condition. The fuses shall blow to clear any failure permitting reverse conduction. A blown fuse indicator shall be visible from outside the rectifier enclosure. Alternative to fuses shall require District approval.

8. The number of diodes per leg shall not exceed 10 for 3-MW and 4-MW units, and 12 for 5-MW units, unless otherwise approved by the District.

D. Terminations

1. The rectifier shall be connected to its associated rectifier transformer through a metal enclosed busway with cables or braided copper connections on the transformer end to reduce bus vibration as indicated.

2. The rectifier DC output shall be connected either through a metal-enclosed positive bus or cables to its associated 1000 VDC switchgear.

3. The throat connections between equipment and busways shall be designed for close coupling and for installation and removal without the necessity of moving the transformer, rectifier, or DC switchgear.

4. Flanges shall be provided with gaskets to prevent entrance of moisture.

5. The negative DC terminal of each rectifier section shall be bus-connected to the negative disconnect switch through a metering shunt.

6. Configure the incoming negative cable connections to the negative disconnect switch to be in an enclosed negative bus box compartment separate from the rectifier. The only negative cables entering the rectifier shall be cable connections to the negative bus box.

E. Negative Disconnect Switch

1. The rectifier shall be furnished with a negative disconnect switch, that shall be:

   a. No-load, single-pole, single-throw, non-ferrous, non-magnetic, with solid copper current- carrying parts and silver-plated contacts. The switch shall be manually operated, bolted- pressure type, rated for at least 1000 VDC nominal, and with current ratings matching the overload and short-circuit capability of the rectifier.

   b. Provided at a minimum with one normally-open and one normally-closed auxiliary contact.

   c. Designed with ample space and contact surface for pulling and terminating the negative cables from the negative bus enclosure.

   d. Key-interlocked with the associated DC main circuit breaker, so that the switch can be operated only with the main breaker in the open and withdrawn position.

   e. Equipped with insulated handle.

2. NEMA 2-holes standard connectors shall be furnished for the cable terminations as indicated.

3. A viewing window shall permit inspection of the disconnect switch position without opening the rectifier compartment.

F. Relaying, Metering, and Indicating Devices

1. Relaying, metering, and indicating devices shall be provided as indicated.

2. Temperature-measuring devices (126DT) shall be installed to detect an abnormal rise in diode heat sink temperatures. Each device shall have at least two stages. First stage contact shall be for local and remote annunciations and the second stage for breaker tripping. The pickup point of each stage shall be adjustable and factory-set so that upon the heat sink temperature reaching the preset level the corresponding contact shall initiate an alarm or trip the station circuit breakers through the lockout relay (Device 286) as indicated.

3. Monitoring devices (180DM) shall be furnished to detect the loss of one or more diodes:

   a. Failure of any diode in any string shall initiate local and remote alarms.

   b. Failure of a second diode in a rectifier bridge shall initiate the tripping of the substation circuit breakers via a lockout relay (Device 286) as indicated.

   c. Rectifier doors to normally energized buses or components and to the negative disconnect switch shall be electrically interlocked to trip the AC and DC cathode circuit breakers through the lockout relay (Device 286), when a door is opened as indicated.

4. Control and Communication Function:

   a. Provide the following:

      1) Binary (device contact) inputs, for collection and inclusion in custom control logic, and signal re-transmission.

      2) IOM connected by hardwire to protection devices and connected to C02 control panel via fiber optic cable over an Ethernet connection.

      3) Internal programmable logic controller (PLC) capability, including:

         a) User-defined logic

         b) Programmable function keys

         c) Ethernet interface capability

         d) Binary (relay contact) outputs, for interface with other relays and for circuit breaker control capability.

   b. Coordinate with the CO2 panel design to implement controls, indications, and data transfer between the transformer-rectifier protection devices and the CO2 panel for local and remote control, indication, and data transfer functions and processes.

2.06 FACTORY TESTING

A. General: Testing shall be performed in accordance with the requirements specified in Section 01 45 24, Testing Program Requirements.

B. Transformer-Rectifier Units

1. The following design tests shall be performed on one transformer-rectifier unit complete with accessories. Unless specified otherwise the tests shall be performed with equipment fully assembled.

    a. Basic Performance Parameters. Design tests shall be performed to verify the efficiency, voltage regulation, displacement power factor, and diode current balance at loads of 0, 25, 50, 75, 100, 150, 300, and 450 percent of rated load.

    b. Temperature Rise Test

        1) Locate the temperature probes in accordance with the industry standards, and use the test results from the individual probes to calculate the expected temperature rise on all components of the involved equipment, and to verify that local temperatures of the transformer, the rectifier are within the limits indicated in IEEE C57.12.90, IEEE C57.12.00, and IEEE C57.18.10.

        2) The transformer-rectifier units shall be operated at 100 percent full-load until all parts have reached constant temperature before applying overloads. Constant temperature is deemed to be reached if the temperature rise change of any part becomes less than one degree Celsius per hour.

        3) After constant temperature has been reached, the transformer-rectifier unit shall be operated at 150 percent full load for two hours with five cycles of 300 percent full load for one-minute duration, each equally spaced throughout the two-hour period, followed by one period of 450 percent full load for 15 seconds at the end of the two-hour period.

        4) The temperature rise tests may be performed with shorted rectifier output terminals, and at reduced AC input voltage sufficient to produce the required load currents.

    c. Short-Circuit Test

        1) Bolted short-circuit fault shall be made on the output terminals of the rectifier to verify the capability of the equipment to withstand the maximum fault current without damage. The source shall be three-phase, 34.5 kV AC, with fault level of no less than 500 MVA.

        2) The fault shall be cleared by the AC circuit breaker’s protective devices 250/251, 250N/251N, or 287T, set the same as it will be on the installed system.

        3) Each phase of the AC circuit breaker and the output of the rectifier shall be monitored. Test results of voltages and currents as a function of time shall be recorded on an oscillograph.

d. Noise Level Tests

1) Noise level tests shall be performed on one transformer-rectifier unit including the interphase transformer mounted in its permanent location. Noise level shall be tested during the short circuit test but must be verified after rectifier installation on the real system while loaded and shall subject to IPT replacement if exceed the prescribed noise level.

2) The noise level at full load, measured in accordance with NEMA TR1 and IEEE C57.12.90, shall not exceed the specified levels.

e. Tests to establish the transformer-rectifier unit efficiency, voltage regulation, and power factor at 0, 1, 25, 50, 75, 100, 150, 200, and 300 percent of rated load. The tests shall be used to determine the required parameters by direct measurement; or, where direct measurement is not possible, the Contractor shall conduct tests to obtain data for the indirect derivation of the required parameters via calculations.

2. Production Tests: perform per IEEE requirements.

C. Rectifier Transformers

1. The following design tests as applicable to power-type transformers listed in IEEE C57.12.90, IEEE C57.18.10, IEEE 1653.2, and NEMA TR1 shall be performed on one rectifier transformer of each size:

a. Dielectric tests: impulse tests. Tests shall include one application of a reduced full-wave, two applications of a chopped wave, followed by one application of a full-wave. These tests shall be performed after the short-circuit tests and temperature rise tests on the rectifier transformer.

b. Audible noise test as in NEMA TR1 and IEEE C57.12.90

c. Impedance and load loss at rated current on the rated voltage connections and on all taps.

d. Commutating reactance and resistance per IEEE C57.18.10

e. Short-circuit tests, as described in IEEE C57.12.00 and IEEE C57.12.90, shall be performed to evaluate fully the capability of all windings. At least one extreme of the tap range shall be used in the tests. Short-circuits shall be applied on the secondary terminals of each winding.

2. The following production tests shall be performed on rectifier transformers in accordance with IEEE C57.18.10 and IEEE 1653.2:

a. Resistance and impedance measurements including zero sequence impedance of all windings on the rated voltage connection of each unit and at all taps.

b. Ratio tests at the rated voltage on all tap changer connections.

c. Phase-rotation tests on the neutral tap connection.

d. No-load loss at rated voltage on the neutral tap connection.

e. Excitation current at rated voltage on the neutral tap connection.

f. Dielectric tests: low frequency withstand, including applied and induced potential tests.

g. Load losses and impedance voltage at rated current on the rated voltage connections and on all taps.

h. Partial-discharge tests: The partial discharge test shall be in accordance with IEEE C57.12.00 and IEEE C57.113, and shall be used to verify that the transformer insulation is free of partial discharges for voltages up to 120 percent of the rated primary voltage.

D. Interphase Transformers

1. The following tests shall be performed on the interphase transformers in accordance with IEEE C57.12.91:

a. Resistance measurement

b. Reactance excitation current and core loss measurements

c. Calculated DC loss at rated load

d. Insulation resistance test between windings and core

e. Applied voltage or Hi-pot test at the test voltage level of the rectifier.

E. Rectifiers

1. Design tests shall be performed on one rectifier, including the diode protection, monitoring and alarm functions, in accordance with IEEE 1653.2. Design tests shall also be performed on the negative disconnect switch in accordance with ANSI C37.45.

a. Diode types for use in the rectifier shall be fully tested in accordance with JESD282B.01.

1) Include in these reports two copies of the registration format outlined in JESD282B.01.

2) The test results shall be certified by both the diode manufacturer and the rectifier manufacturer.

b. End points for all tests shall be well beyond any maximum values to be expected under any loading conditions. Diodes shall be dated as specified using the four-digit code and shall meet or exceed Class B requirements in accordance with JESD282B.01.

c. Rectifier-type instruments shall not be used in making any of the specified tests. In general, limiting or end point values for reverse current or forward voltage drop shall be at least twice the maximum rated values listed in the registration format. Each curve shall be clearly labeled to show test conditions and shall show actual data points.

2. The following production tests indicated in IEEE 1653.2 shall be performed on rectifier units:

    a. Dielectric strength test.

    b. Rated voltage test.

    c. Rated current test, including current imbalance, with the latter:

        1) Between phases

        2) Between each diode in each phase

    d. Diode protective, monitoring, and alarm functions.

    e. Applicable tests identified as production tests in IEEE C37.41 for the negative disconnect switch.

2.07 SYSTEM FACTORY FUNCTIONAL TESTING

A. Refer to Section 34 21 75, Traction Power Facility System Factory Functional Testing for requirements.

PART 3 – EXECUTION

3.01 FIELD ACCEPTANCE TESTING

A. Refer to Section 34 21 80, Traction Power System Field Acceptance Testing, for requirements.

END OF SECTION 34 21 21

SECTION 34 21 22

TRANSFORMER-RECTIFIER UNITS – DRY TYPE TRANSFORMER, UNCONTROLLABLE RECTIFIER

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. General

B. Overload requirements

C. Ratings

D. Transformer – rectifier unit

E. Factory testing

F. System factory functional testing

G. Field acceptance testing

1.02 RELATED SECTIONS

A.	Section 01 33 00	Submittal Procedures
B.	Section 01 33 23	Shop Drawings, Product Data, and Samples
C.	Section 01 43 00	Quality Assurance
D.	Section 01 45 00	Quality Control
E.	Section 01 78 23	Operation and Maintenance Data
F.	Section 01 45 24	Testing Program Requirements
G.	Section 07 41 00	Sample Conformed Contract Specifications
H.	Section 34 21 01	General Requirements for the Traction Power System
I.	Section 34 21 07	Prefabricated Portable Substations
J.	Section 34 21 25	DC Switchgear
K.	Section 34 21 75	Traction Power Facility System Factory Functional Testing
L.	Section 34 21 80	Traction Power System Field Acceptance Testing

1.03 MEASUREMENT AND PAYMENT

A. Measurement: Dry type transformer and uncontrolled rectifier units will be measured for payment per individual unit of each type that is tested and furnished in accordance with the Contract Documents.

B. Payment: Dry type transformers and uncontrolled rectifier units will be paid for at the Contract unit price per each individual unit of each type as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. American National Standards Institute (ANSI):

1. ANSI C37.45 Standard Specifications for High-Voltage Distribution Class Enclosed Single-Pole Air Switches with Rated Voltages from 1 kV through 8.3 kV.

B. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE C37.41 Standard Design Test for High Voltage (>1000) Fuses and Accessories.
2. IEEE C57.12.01 Standard for General Requirements for Dry-Type Distribution and Power Transformers.
3. IEEE C.57.12.29 Standard for Pad-Mounted Equipment – Enclosure Integrity for Coastal Environment.
4. IEEE C57.12.70 Standard Terminal Markings and Connections for Distribution and Power Transformers.
5. IEEE C57.12.91 Standard Test Code for Dry-Type Distribution and Power Transformers.
6. IEEE C57.18.10 Standard Practices and Requirements for Semiconductor Power Rectifier Transformers.
7. IEEE C57.113 Recommended Practice for Partial Discharge Measurement in Liquid-Filled Power Transformers and Shunt Reactors.
8. IEEE C57.124 Recommended Practice for the Detection of Partial Discharge and the Measurement of Apparent Charge in Dry-Type Transformers.
9. IEEE 519 Recommended Practice and Requirements for Harmonic Control in Electric Power Systems.
10. IEEE 1653.1 Standard for Traction Power Rectifier Transformers for Substation Applications up to 1500V DC Nominal Output.

11. IEEE 1653.2 Standard for Uncontrolled Traction Power Rectifiers for Substation Applications up to 1500V DC Nominal Output.

C. National Electrical Contractor's Association (NECA):

1. NEIS National Electrical Installation Standards.

D. National Electrical Manufacturer's Association (NEMA):

1. NEMA TR 1 Transformers, Regulators and Reactors.

2. NEMA RI-9 Silicon Rectifier Units for Transportation Power Supplies (Withdrawn).

E. National Fire Protection Association (NFPA):

1. NFPA 70 National Electrical Code (NEC).

F. JEDEC Solid State Technology Association:

1. JESD282B.01 Silicon Rectifier Diodes.

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures; and Section 01 33 23, Shop Drawings, Product Data, and Samples for submittal requirements and procedures.

B. Product Data: Submit product data to include the following:

1. Physical arrangement and assembly drawings of rectifier transformer and traction rectifier.

2. Wiring connections.

3. Shop drawings.

4. Brief description of devices and their functions and protective relay settings.

5. Equipment nameplate.

6. Transformer data including rated kVA, frequency, primary and secondary voltages, percent taps, polarity, impedance and certification of transformer performance efficiency at indicated loads, percentage regulation at 100 percent and 80 percent power factor, no-load and full load losses in watts, percent impedance at 75 degrees Celsius, hot-spot and average temperature rise above 40 degrees Celsius ambient temperature, sound level in decibels, and standard published data.

7. Product data for traction rectifier including diodes, fuses, heat sinks, over-voltage protection devices, fuse monitoring, and door interlocks.

C. Design calculations for the transformer-rectifier unit, including extended voltage regulation curve from light transition load to short-circuit condition, no-load voltage, power factor as function of loading, efficiency as function of loading, harmonics on the DC and AC side, and sizing of dummy (base) resistor.

D. Test plan and procedures for factory testing of the rectifier transformer.

E. Test report for factory testing of the rectifier transformer.

F. Test plan and procedures for factory testing of the traction rectifier.

G. Test report for factory testing of the traction rectifier.

H. Test plan and procedures for factory testing of the transformer-rectifier unit.

I. Test report for factory testing of the transformer-rectifier unit.

J. Test plan and procedures for field testing of the rectifier transformer.

K. Test report for field testing of the rectifier transformer.

L. Test plan and procedures for field testing of the traction rectifier.

M. Test report for field testing of the traction rectifier.

N. Test plan and procedures for field testing of the transformer-rectifier unit.

O. Test report for field testing of the transformer-rectifier unit.

P. Installation Manual. Submit manufacturer recommended procedures for installation of the transformer-rectifier unit.

Q. Operation and Maintenance Manuals: Provide the following operations and maintenance manuals in accordance with Contract Specification Section 01 78 23, Operation and Maintenance Data.

R. Design calculations for the rectifier transformer, including power rating, windings turn ratio, impedance, commutating reactance, no-load losses, full-load losses, performance over specified temperature range, and seismic calculations.

S. Design calculations for the traction rectifier, including determination of the number of diodes per rectifier leg, continuous current and short-term overload capability, fuse ratings and transient voltage suppression devices.

T. Rectifier transformer mounting, cable or busway entry, and conduit design for cable connections to the rectifier transformer shall be submitted for review and acceptance by the Engineer.

U. Plan of design techniques, construction methods, and equipment employed to protect against transient surge voltages.

V. Submit proof in the form of calculations or empirical data that the rectifier transformer meets the noise level requirements.

W. Submit the methods and procedures for replacement of the rectifier transformers.

X. Submit paint type and color to be reviewed and approved by the Engineer.

Y. Submit a recommended spare parts list.

1.06 QUALITY ASSURANCE AND SUPPLIER QUALIFICATIONS

A. Electrical components, devices, and accessories shall be listed and labeled in conformance with the NFPA 70, Article 100. Electrical components, devices, and accessories and their installation shall comply with NECA's National Electrical Installations Standards (NEIS).

B. Transformers and rectifiers shall be proven standard products, or equivalent to the standard products of manufacturers engaged in the production of such equipment for at least the past five years.

C. The manufacturer of the rectifier transformers must have a minimum of five years manufacturing experience with three-winding, dry type power transformers, utilizing IEEE 1653.2 Circuit 31 configurations.

D. The engineer responsible for the design of the rectifier transformers and rectifier shall have a minimum of five years of project-proven experience in the design of three-winding rectifier transformers.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Delivery, loading/unloading, handling, storage, and protection of transformer shall be in accordance with manufacturer's guidelines.

B. Equipment shall be packaged for arrival at the Jobsite undamaged by handling and weather.

C. Temporary braces, guides, skids, crates, and other shipping devices necessary for transporting and temporary storage of the equipment shall be furnished. Temporary bracing shall be labelled "Remove Before Operation".

D. Equipment shall be protected against corrosion, dampness, damage due to vibration, and other damage during transportation and handling. Openings to the external environment shall be sealed before shipping. Products shall be packed in weatherproof containers for storage outdoors.

E. Impact Recorder: Impact recorder is required for shipping to and from test locations and from the supplier's facility to the District, and a report shall be submitted to the Engineer for each travel segment. Submit recordings for each travel segment within 24 hours of the completion of each trip.

1.08 WARRANTY

A. A warranty for the rectifier transformers, traction rectifiers, and associated system components shall be provided and signed by the manufacturer and installer agreeing to correct system deficiencies and replace components that fail in materials or workmanship. The warranty shall be for the period of five years from the date of issuance of the Substantial Completion of each substation.

PART 2 – PRODUCTS

2.01 GENERAL

A. The Supplier shall coordinate the requirements of associated substation equipment to provide a 1000 V DC traction power supply.

B. Transformer windings, rectifier buses, and interconnecting AC buses shall be made of copper conductors.

C. The transformer-rectifier units shall be designed and fabricated in accordance with the latest revision of the applicable ANSI, IEEE, and NEMA standards as listed in Section 1.04.

D. Each unit shall consist of a rectifier transformer and a traction rectifier with necessary hardware, wiring, and devices as indicated, and as required for a complete and operating installation.

E. The rectifier transformer shall receive 34.5 kV, three-phase, 60 Hz, 3-wire power from 34.5 kV vacuum fault interrupter switchgear and shall transform the high voltage to a low AC voltage rated as required by the traction rectifier.

F. The rectifier transformer shall be designed with an enclosure for outdoor use.

G. Rectifier transformer shall be housed in portable substation house trailer as specified in Section 34 21 07, Prefabricated Portable Substations and shall meet requirements for underground devices in and IEEE C57.12.29.

H. Rectifier transformer shall be mounted to the 34.5 kV switchgear and rectifier transformer house trailer as shown in the Contract Drawings.

2.02 OVERLOAD REQUIREMENTS

A. The transformer-rectifier unit shall be rated for extra heavy-duty traction load. The unit shall be able to operate at the following overload cycle, beginning from operation at nominal load and stabilized temperature:

1. 150 percent of rated current for 2 hours, with superimposed 5 periods of 1 minute duration at 300 percent of rated current each, equally spaced throughout the 2-hour period.

2. 450 percent of rated current for 15 seconds at the end of the two-hour period.

B. The transformer-rectifier unit shall withstand two overload periods as specified above on a daily basis, spaced 8 hours apart, each preceded and followed by the continuous 100 percent load level.

C. The transformer-rectifier units shall be designed to meet the above daily duty cycle without damage to any parts or the insulation for a period of 25 years.

D. Current unbalance caused by loss of one diode per phase shall be taken into consideration in the design, and shall not reduce the specified overload capability of the rectifier.

2.03 RATINGS

A. Unit Capacity

1. The kW rating of the transformer-rectifier units shall be as indicated. The units shall be designed to deliver the rated kW output at rated terminal voltage.

2. The units shall withstand continuous operation at 110 percent rated voltage without exceeding the equipment temperature limitations.

B. Efficiency: The overall efficiency of the transformer-rectifier shall be greater than 97.5 percent at its continuous rating. No-load core losses shall not exceed 0.25 percent of the rated unit capacity.

C. Power Factor: The displacement power factor of the transformer-rectifier units shall be 0.95 or greater from 25 percent to full load with rated AC input voltage.

D. Voltage Regulation: The transformer-rectifier units' initial regulation shall be 6 percent. The regulation shall be linear from light transition (1 percent) load to at least 300 percent of full load. Manufacturing tolerance shall not exceed 10 percent of the specified regulation value. The voltage at the rectifier output at no-load shall not exceed 1350 V DC at rated primary voltage of 34.5 kV. The light transition load voltage shall be approximately 1,060 V DC at the rated primary voltage of 34.5 kV, while the full-load (nominal) voltage shall be 1000 V DC, with plus-or-minus 6 V maximum deviation allowed for manufacturing tolerance.

E. Short-Circuit

1. Each transformer shall be designed to withstand a full short-circuit at the low-voltage terminals at rated voltage on the high-voltage terminals for one second, in accordance with IEEE C57.12.01 and C57.12.91.

2. Components of the rectifier unit, including the terminal connections and buswork, shall be designed to withstand a bolted fault on the DC positive bus, without damage, for the time period required for the backup protection to operate and open the 34.5 kV vacuum fault interrupter.

3. The transformer shall be designed to withstand the short-circuit power available from the 34.5 kV subtransmission lines at the switching stations which is expected to be up to 500 MVA.

4. The secondary windings of the rectifier transformer shall be coupled magnetically, so that at a given fault level of 500 MVA at 34.5 kV, the sustained short circuit current on the rectifier bus for a bolted fault does not exceed nine times the full load current.

F. Additional Rating Requirements:

1. See Section 2.04 for rectifier transformer ratings.

G. Voltage Transients

1. Transformer-Rectifier unit shall be protected against transient surge voltages per IEEE 1653.2.

2. If fuses are used in surge suppression networks, they shall be monitored by visual indicators, and shall be equipped with devices capable of being monitored both locally and remotely.

3. A surge protection network at the input terminals shall protect each rectifier unit from damage due to switching voltage transients up to 2.5 times normal voltages in the 34.5 kV AC system. Failure of the surge protection network shall be annunciated both locally and remotely as indicated.

4. A static voltage surge suppressor rated to withstand expected voltage transients, shall protect each rectifier from lightning surges transmitted along DC contact rails and from voltage transients on the DC system due to breaker switching. A counter shall be provided for the surge suppressor. Failure of the surge suppressor shall be annunciated both locally and remotely as indicated.

5. The surge suppressor shall absorb surge energy of 50 kilojoules minimum with bus potential below 2600 volts at instantaneous current of 4000 amperes.

6. The peak value of contact rail transient voltages are expected to be 3000 volts for 8 milliseconds or 6000 volts for 50 microseconds with rise time of 1.2 microseconds.

H. Noise Levels

1. Equipment design, enclosures with acoustic mitigation capability, and other measures, as appropriate, shall be employed to achieve compliance with the specified audible noise level criteria.

2. The noise level measured at a distance of 15 feet from the rectifier transformer enclosure with the transformer operating at 100 percent load and nominal voltage shall not exceed 65 dBA.

2.04 TRANSFORMER – RECTIFIER UNIT

A. Rectifier Transformer:

1. The rectifier transformer shall comply with the requirements of IEEE C57.12.01, C57.12.91, ANSI C57.18.10, IEEE 1653.1, and NEMA TR 1. Each rectifier transformer shall be solid cast coil or resin encapsulated type, self-cooled, three-phase, 60 Hz, three-winding, suitable for outdoor service for the duty cycles indicated. Each cast coil shall be cast under vacuum to ensure complete, void-free epoxy resin impregnation throughout the insulation system. Coils for resin encapsulated type transformers shall be fabricated using the multi-cycle vacuum pressure encapsulation (VPE) process. Resin encapsulated type transformer manufactured with vacuum pressure impregnation (VPI) followed by encapsulation with a polyester resin mixture are acceptable.

    a. Winding Connections. High and low voltage windings shall be copper. Winding insulation shall be 180 degrees Celsius for cast coil and 220 degrees Celsius for VPI/VPE. High-voltage windings shall be three-phase, 60 Hz, 34.5 kV Class with a minimum BIL of 150 kV. Low-voltage windings to be six-phase with a minimum BIL level of 30 kV. High voltage winding connectors to vacuum fault interrupter switchgear shall be made of #2/0, 35 kV EPR cable entering from below as indicated in the Contract Drawings.

    b. Temperature Rise:

        1) Winding Temperature Rise above 50 degrees Celsius ambient after stabilized continuous operation at 100 percent load: 55 degrees Celsius.

        2) Hottest-Spot Temperature Rise above 50 degrees Celsius ambient after stabilized continuous operation at 100 percent load: 85 degrees Celsius.

    c. Impedance. Select the transformer impedance to provide the specified rectifier output voltage as specified in Section 2.04B, Rectifiers.

    d. Taps. The high voltage windings to have four 2.5 percent, full capacity off-load taps, two above and two below the rated voltage of 34.5 kV. Tap changing shall be by movable links. Tap connections shall be brought out and rigidly supported on a terminal board located in the transformer enclosure, and be accessible through removable access panels. Access panels shall contain observation windows for observing the connected tap. Tap connections shall be clearly marked so that the tab selected is clearly identifiable through the observations window.

    e. The tap changing links shall be securely bolted in position. The design of links and connectors shall make it impossible to short out sections of windings, or to select taps outside the prescribed range, by incorrectly connecting the links.

f. Accessories. Provide standard and indicated accessories and protective devices. Contacts shall be electrically separate. Provide a winding temperature indicator, Device 249, with maximum reading pointer to detect transformer winding over-temperature and with a factory set, two-stage contact. Provide the first stage with a normally-closed contact that opens on temperature increase to initiate local and remote supervisory control annunciations. Provide the second stage with a normally-open contact that closes on temperature increase to initiate tripping of the unit lockout relay, Device 286.

g. Provide lugs required for cable interconnections between rectifier-transformer and rectifier and rectifier. Size and number of NEMA 2-hole lugs shall be as indicated.

h. Assembly. Design the transformer so that parts that require maintenance are readily accessible.

1) Transformer Enclosure. Enclose the transformer in a rigid, self-supporting and self-contained, electrically-welded, outdoor steel structure. Design the structure to be sufficiently rigid to withstand maximum short-circuit currents. Provide bolt-on doors on front and rear of enclosure to permit ready access for inspection and maintenance. Provide door switch (33T) on transformer doors. Operation of door switches shall initiate local and remote supervisory control annunciations and operate the unit lockout relay, Device 286. Provide nameplate in accordance with IEEE C57.18.10.

2) Lifting Hooks. Provide lifting hooks or eyes on the transformer core and coil assembly and on the enclosure to facilitate lifting parts of the unit separately.

2. Construction Requirements

a. Transformers shall be replaceable.

b. Transformers indicated for portable use shall be designed for trailer mounting, and shall be designed such that their portability does not reduce their specified service life. Transformer parameters, including overall dimensions and weight, shall be coordinated with the design of the Supplier supplied prefabricated portable substation and trailer. Refer to the requirements of Contract Specifications Section 34 21 07, Prefabricated Portable Substations.

c. Transformers indicated for permanent mounting shall be designed for installation as indicated (e.g., on a steel floor within a prefabricated portable module). Floor loading: Transformer base shall be compatible with floor design loading of 250 pounds per square foot.

d. Transformer supporting steelwork and enclosures shall be painted as indicated.

e. Transformer shall meet the following:

1) Provide nameplate with connection diagram and tap arrangement.

2) Provide warning signs as required.

3) Provide ancillary equipment control cabinet on the outside of transformer enclosure housing the alarms and trip signals due to activation of the protective devices including control power alarms shall be communicated via the I/O module located in the control cabinet. These signals shall be transmitted via for the optic cable to the C02 panel at the DC switchgear house.

4) The main transformer control cabinet shall have thermostatically controlled anti condensation heaters rated for 120 V single phase power supply.

f. Base Construction:

1) The structural steel base shall consist of at least two members parallel to the transformer major axis and at least two members parallel to the minor axis.

2) Base construction shall firmly secure the core to prevent relative motion of the core during shipment, handling, and seismic shock.

3. Transformer Enclosures:

a. Panels comprising the transformer enclosure including doors shall be constructed of sheet steel, not less than No. 11 gauge, and mounted on rigid, self-supporting structural steel framework.

b. Glastic-type insulation shall be provided between the low voltage AC busway and the uncontrolled rectifier unit.

c. Convenient access, including doors on both front and rear sides, shall be provided for maintenance and inspection of the transformer.

d. Each enclosure door shall be equipped with:

1) A mechanical latch to hold the door closed. Mechanical latches shall withstand seismic events for which the rectifier transformer is rated.

2) Door stays to hold the door open for inspection of rectifier transformer components.

e. Openings and mounting holes for front-mounted indicating and control devices shall be cut out, drilled, or punched without marring or distorting the exposed finished surfaces of the control cubicles.

f. Separate compartments shall be provided to isolate control and auxiliary circuits and functions.

g. Readings, controls, and observations shall be made without the exposure to live parts.

h. Frame and base design shall be sufficient to comply with floor design loading of 250 pounds per square foot.

i. If transformer is not to be placed on a trailer, base shall be suitable for skidding the transformer unit in any direction on rails or rollers and have jacking facilities at each corner.

j. Grounding bus integral to the transformer enclosure shall be provided and connected to the transformer core and supporting steelwork. The transformer enclosure shall be provided with two (2) grounding pads on opposite sides, suitable for connection to the substation ground grid. If the transformer is mounted on a trailer, bond transformer ground pads to the trailer frame and ensure trailer frame is connected to the facility ground grid.

4. Core:

a. Core and Coil Assembly:

1) Joints in winding or at terminals shall be either brazed or clamped.

2) Core-bolt insulation shall be high-temperature resistant. Stepped mitered lap core construction and entire assembly shall be braced or bolted adequately to prevent displacement and distortion under normal conditions of handling and operation under normal, overload, and short circuit conditions.

3) Bolted core members and connections shall be made by at least two bolts equipped with locknuts and lock washers.

4) Serial number shall be stamped on core in a conspicuous place.

5) Core laminating shall be high-grade, non-aging, grain oriented silicon steel with high magnetic permeability, low hysteresis and eddy current loss. Magnetic flux densities shall be kept below saturation to allow for a minimum of 10 percent overvoltage excitation. The outside surfaces of the core shall be protected against corrosion by a resin coating.

6) The core shall be stacked in the step or cruciform method to best accommodate a round coil.

7) Core lamination shall be free of burrs and stacked without gaps.

8) The individual coil shall be assembled on the core and arranged coaxially so that the electrical centers are reasonably matched.

9) Even compression on the coils shall be maintained throughout the transformer’s complete temperature range. The compression shall also remain constant in case of unequal movement of the primary and secondary coils.

10) Coils shall be supported axially by bottom supports and constant pressure blocks, with the blocks support the coil concentrically. The core clamping structure shall be of rigid construction and designed to provide full clamping pressure on the core and to provide locations for applying blocking and jacking points to support the coils. The top and bottom core clamps shall maintain constant pressure through the life of the transformer’s complete temperature range. The core shall be adequately clamped to prevent excessive humming and chattering.

11) Core and coil shall be mounted on vibration suppressors within the enclosure if necessary to keep the noise level of the transformer below 65 db.

5. Windings:

   a. The High Voltage winding shall be thoroughly reinforced with fiberglass matting to adjust the expansion so that it is close to that of the copper conductor.

   b. Fiberglass matting shall reinforce the winding so that the winding will withstand thermal stresses during the load cycle. The fiberglass matting shall enhance the pure epoxy or polyester to increase its mechanical strength, arc resistance, and adhesion to the conductor, plus change its coefficient of expansion to be closer to that of the conductor. The vacuum cast coils shall be reinforced with fiberglass mat.

   c. The finished primary and secondary coils shall be hermetically sealed in epoxy or polyester utilizing a proven manufacturing process demonstrating its ability minimize hot spots and partial discharge. Control, auxiliary power, and alarm circuits shall be completely wired in the factory. Wiring shall run in the rigid metallic raceway, with an exception for watertight fittings to be used on runs of two feet or less. Auxiliary connections to external circuits shall be brought to one NEMA 3R junction box and terminated on terminal blocks. Manufacturer shall provide documentation supporting the temperature rating of 150 degrees Celsius.

   d. The rectifier transformer primary windings shall be close coupled with the secondary windings.

6. Special Tools:

   a. Special tools required for installation and maintenance of the equipment shall be identified by the manufacturer at time of bid.

7. Marking:

   a. Every transformer shall be provided with a rating plate showing the information required by IEEE 1653.1.

   b. The rating plate shall indicate the type of conductor used for both high voltage and low voltage windings (e.g., copper).

   c. The rating plate shall indicate that the transformer is constructed for Heavy Traction Duty as defined in IEEE C57.18.10.

   d. The rating plate shall show the physical layout of tap board and the turns ratios.

B. Rectifier:

1. General

a. Each rectifier bridge or section shall be a complete self-contained unit consisting of silicon diodes, heat sinks, protective fuses, natural ventilation system, copper buses and bus connections, enclosure with doors, hardware, gaskets, and other necessary accessories and devices.

b. The rectifier shall be indoor type, with natural convection-cooling, and shall be designed to operate at 50 degrees Celsius ambient temperature.

c. The rectifier shall consist of two six-pulse, delta-wye, double-way circuits each having six legs of diode devices connected to the transformer delta wye secondary windings, per IEEE 1653.2 circuit No. 31.

d. An interphase transformer shall be provided between the direct outputs of the two six-pulse sections to absorb the instantaneous direct voltage differences. To achieve the lowest practical noise level, the core of the interphase transformers shall be designed to minimize the magnetostriction. Magnetostriction is the phenomenon of elastic deformation that accompanies magnetization. Noise damping treatment may be accepted in reducing the noise level by canceling some of the noise frequencies of the interphase transformer. However, the Supplier shall submit calculations showing that any noise treatment allows rectifier ventilation that meets the specifications. The Supplier shall submit calculations showing that the noise level expected for the transformer under full load or maximum excitation meets the specified noise level limits for the transformer-rectifier unit per Article 2.03H herein. The calculations shall demonstrate adequate magnetic core material is used to accept expected IEEE 1653.2, extra heavy-duty rectifier loading with a noise level that meets the Contract Specifications. The calculations shall be signed by a California registered professional engineer specialized in noise suppression field.

e. Materials shall be chosen to preclude the possibility of corrosive or galvanic action between dissimilar metals. Compatible materials shall be used for diode cases, studs, and heat sinks.

f. The rectifier enclosures shall be designed for high-resistance type enclosure-to-ground protective relaying.

2. Rectifier Enclosures

a. Panels comprising the rectifier enclosure including doors shall be constructed of sheet steel, not less than No. 11 gauge, and mounted on rigid, self-supporting structural steel framework.

b. Insulation shall be provided between the rectifier and the DC main breaker cubicle and between the rectifier and the negative return cabinet. Adequate electrical insulation shall be provided between the rectifier enclosure and the AC busway from the rectifier transformer, such that a person cannot simultaneously touch the rectifier enclosure and any adjacent ground structure.

c. Louvered or mesh openings shall provide ventilation and air-cooling of the components by natural convection.

d. Ventilation intake openings shall be located not less than six inches above the floor.

e. Heat transfer surfaces and ducts shall be designed with smooth surfaces that minimize accumulation of dust and other contaminants.

f. Convenient access, including doors on both front and rear sides, shall be provided for maintenance and inspection of the rectifier.

g. Each enclosure door shall be equipped with:

   1) A mechanical latch to hold the door closed and

   2) Door stops to hold door open for inspection of rectifier components.

h. Openings and mounting holes for front mounted indicating and control devices shall be cut out, drilled, or punched without marring or distorting the exposed finished surfaces of the control cubicles.

i. Rectifier enclosure shall be furnished with viewing windows so that blown-fuse indicators and the position of the negative disconnect switch can be seen from the outside, without opening the rectifier doors.

j. Separate compartments shall be provided to isolate control and auxiliary circuits and functions from the 1000 V DC buses and diodes.

k. Readings, controls, and observations shall be made without exposure to live parts. Internal lights with an external switch shall be included. Lighting fixtures shall be provided with guards.

l. Components installed in the rectifier shall be capable of withstanding 4600 V DC for one minute, applied between completely assembled rectifier and ground, with control circuits connected and energized or grounded, except that ground connection to the 164A/164G relay shall be disconnected and its contact set in the OPERATE (tripped) condition.

m. Provide rectifier unit with provisions to establish rectifier electrical clearance such that potentials inside the rectifier enclosure are connected together with conductors capable of withstanding a fault if the rectifier unit is inadvertently energized for at least 0.5 seconds for protection devices to clear the fault. AC incoming power supply, DC positive, DC negative, and the rectifier frame shall be connected together to provide adequate and safe physical access for maintenance of the rectifier unit by maintenance personnel. The enclosure shall be connected to the high resistance ground relay (Device 164A/164G) as indicated.

n. Devices mounted within rectifier enclosures that use 125 V DC control power from an external power source, and where no means is used to electrically isolate the circuit, shall be mounted on glastic type insulating material to electrically isolate the device from the structure.

3. Diodes

    a. Diodes shall be rated and tested in accordance with JESD282B.01. Parallel strings of diodes shall be geometrically similar and as symmetrical as practicable to balance the normal and surge electrical characteristics of each string.

    b. In addition to the parallel strings necessary to handle loads, as specified, additional capacity shall be provided so that, with one diode per phase leg out of service, each current path will still handle specified loads and maximum short circuit current.

    c. Each diode shall be able to withstand, at its maximum operating temperature, voltages 2.5 times higher than the no-load AC bus voltage of the rectifier, without a permanent change in diode characteristics.

    d. The maximum current unbalance between parallel strings in each phase and between phases shall be such that the removal of any one diode per phase does not impact the required thermal capacity or short-circuit withstand capability of the rectifier.

    e. Each parallel diode string shall be protected against internal short circuits by a current-limiting, fast-acting fuse equipped with a microswitch for local and remote status indications, and visible blown-fuse indicator.

    f. Diodes shall have uniform voltage division within plus or minus ten percent across each diode.

    g. Each parallel diode string shall be protected by a current-limiting fuse equipped with an indicator. The fuses shall be sized to withstand any external DC fault or loading condition. The fuses shall blow to clear any failure permitting reverse conduction. A blown fuse indicator shall be visible from outside the rectifier enclosure. Alternative to fuses shall require District approval.

    h. The number of diodes per leg shall not exceed 12 for 5-MW units, unless otherwise approved by the District.

4. Terminations

    a. The rectifier shall be connected to its associated rectifier transformer through a metal enclosed busway with cables or braided copper connections on the transformer end to reduce bus vibration as indicated.

    b. The rectifier DC output shall be connected either through a metal-enclosed positive bus or cables to its associated 1000 V DC main breaker cubicle.

    c. The throat connections between equipment and busways shall be designed for close coupling and for installation and removal without the necessity of moving the transformer, rectifier, or DC main breaker cubicle.

    d. Flanges shall be provided with gaskets to prevent entrance of moisture.

    e. The negative DC terminal of each rectifier section shall be bus-connected to the negative disconnect switch through a metering shunt.

f. Configure the incoming negative cable connections to the negative disconnect switch to be in an enclosed negative bus box compartment separate from the rectifier. The only negative cables entering the rectifier shall be cable connections to the negative bus box.

g. Provide lugs required for cable interconnections between rectifier-transformer and rectifier and between rectifier and DC main breaker. Size and number of NEMA 2-hole lugs shall be as indicated.

5. Negative Disconnect Switch

a. The rectifier shall be provided with a negative disconnect switch, that shall be:

1) No-load, single-pole, single-throw, non-ferrous, non-magnetic, with solid copper current-carrying parts and silver-plated contacts. The switch shall be manually operated, bolted-pressure type, rated for at least 1500 V DC nominal, and with current ratings matching the overload and short-circuit capability of the rectifier.

2) Provided at a minimum with one normally-open and one normally-closed auxiliary contact.

3) Designed with ample space and contact surface for pulling and terminating the negative cables from the negative bus enclosure.

4) Key-interlocked with the associated DC main circuit breaker, so that the switch can be operated only with the main breaker in the open and withdrawn position.

5) Equipped with insulated handle.

b. NEMA 2-holes standard connectors shall be provided for the cable terminations as indicated.

c. A viewing window shall permit inspection of the disconnect switch position without opening the rectifier compartment.

6. Control and communication function shall be provided to include:

a. Binary (device contact) inputs, for collection and inclusion in custom control logic, and signal re-transmission.

b. Programmable logic controller (PLC) capability, including user-defined logic.

c. Programmable function keys.

d. Ethernet interface capability.

e. Binary (relay contact) outputs, for interface with other relays and for AC vacuum fault interrupter and circuit breaker control capability.

f. Coordinate with the C02 panel to implement controls, indications, and data transfer between the transformer-rectifier protection devices and the C02 panel for local and remote control, indication, and data transfer functions and processes. Communication between transformer-rectifier protection devices and the C02 PLC shall use the DNP3 protocol.

7. Relaying, Metering and Indicating Devices

    a. Relaying, metering, and indicating devices shall be provided as indicated.

    b. Temperature-measuring devices (126DT) shall be installed to detect an abnormal rise in diode heat sink temperatures. Each device shall have at least two stages. First stage contact shall be for local and remote annunciations and the second stage for AC vacuum fault interrupter and breaker tripping. The pickup point of each stage shall be adjustable and factory-set so that upon the heat sink temperature reaching the preset level the corresponding contact shall initiate an alarm or trip the AC vacuum fault interrupter and DC main breakers through the lockout relay (Device 286) as indicated.

    c. Monitoring Devices (180DM) shall be provided to detect the loss of one or more diodes:

        1) Failure of any diode in any string shall initiate local and remote alarms.

        2) Failure of a second diode in a rectifier bridge shall initiate the tripping of the AC vacuum fault interrupter and DC main breaker via a lockout relay (Device 286) as indicated.

        3) Rectifier doors to normally energized buses or components and to the negative disconnect switch shall be electrically interlocked to trip the AC vacuum fault interrupter and DC main circuit breaker through the lockout relay (Device 286), when a door is opened as indicated.

2.05 FACTORY TESTING

A. General: Testing shall be performed in accordance with the requirements specified in Section 01 45 24, Testing Program Requirements.

B. Transformer – Rectifier Units

1. The following design tests shall be performed on one transformer-rectifier unit complete with accessories. Unless specified otherwise the tests shall be performed with equipment fully assembled.

    a. Basic Performance Parameters. Design tests shall be performed to verify the efficiency, voltage regulation, displacement power factor, and diode current balance at loads of 0, 25, 50, 75, 100, 150, 300, and 450 percent of rated load.

    b. Temperature Rise Test

        1) Locate the temperature probes in accordance with the industry standards, and use the test results from the individual probes to calculate the expected temperature rise on components of the involved equipment, and to verify that local temperatures of the transformer and the rectifier are within the limits indicated in IEEE C57.12.01 and IEEE C57.18.10.

2) The transformer-rectifier units shall be operated at 100 percent full-load till all parts have reached constant temperature before applying overloads. Constant temperature is deemed to be reached if the temperature rise change of any part becomes less than one degree Celsius per hour.

3) After constant temperature has been reached, the transformer-rectifier unit shall be operated at 150 percent full load for two hours with five cycles of 300 percent full load for one minute duration, each equally spaced through the two-hour period, followed by one period of 450 percent full load for 15 seconds at the end of the two-hour period.

4) The temperature rise tests may be performed with shorted rectifier output terminals, and at reduced AC input voltage sufficient to produce the required load currents.

c. Short-Circuit Test

1) Bolted short-circuit fault shall be made on the output terminals of the rectifier to verify the capability of the equipment to withstand the maximum fault current without damage. The source shall be three-phase, 34.5 kV AC, with fault level of no less than 500 MVA.

2) The fault shall be cleared by AC vacuum fault interrupter protective devices 250/251, 250N/251N, set the same as it will be on the installed system.

3) Each phase of the AC vacuum fault interrupter and the output of the rectifier shall be monitored. Test results of voltages and currents as a function of time shall be recorded on an oscillograph.

d. Noise Level Tests

1) Noise level tests shall be performed on one transformer-rectifier unit including the interphase transformer (IPT) mounted in its permanent location. Noise level shall be tested during the short circuit test and shall be field verified after rectifier installation on the real system while loaded. If field verification shows that noise level exceeds specified requirements, equipment shall be modified to provide noise within specified limits.

2) The noise level at full load, measured in accordance with NEMA TR 1 and IEEE C57.12.01, shall not exceed the specified levels.

e. Tests to establish the transformer-rectifier unit efficiency, voltage regulation, and power factor at 0, 1, 25, 50, 75, 100, 150, 200, and 300 percent of rated load. The tests shall be used to determine the required parameters by direct measurement; or, where direct measurement is not possible, the Supplier shall conduct tests to obtain data for the indirect derivation of the required parameters via calculations.

2. Production Tests: perform per IEEE 1653.1 and 1652.2 requirements.

C. Rectifier Transformers

1. The following design tests as applicable to power-type transformers listed in IEEE C57.12.01, IEEE C57.12.91, IEEE C57.18.10, IEEE 1653.2 and NEMA TR 1 shall be performed on one rectifier transformer of each size.

    a. Dielectric tests – impulse tests. Tests shall include one application of a reduced full-wave, two applications of a chopped wave, followed by one application of a full-wave. These tests shall be performed after the short-circuit tests and temperature rise tests on the rectifier transformer.

    b. Audible noise test as in NEMA TR 1, IEEE C57.12.91 and IEEE 1653.1.

    c. Impedance and load loss at rated current on the rated voltage connections and on all taps.

    d. Commutating reactance and resistance per IEEE C57.18.10.

    e. Short-circuit tests, as described in IEEE C57.12.01, IEEE C57.12.91, and IEEE 1653.1, shall be performed to evaluate fully the capability of windings. At least one extreme of the tap range shall be used in the tests. Short-circuits shall be applied on the secondary terminals of each winding.

2. The following production tests shall be performed on rectifier transformers in accordance with IEEE C57.18.01, IEEE 1653.1, and IEEE 1653.2:

    a. Resistance measurements of windings on rated voltage connection and on all taps.

    b. Ratio tests on the rated voltage connection and on all taps.

    c. Polarity and phase relation tests on the rated voltage connection.

    d. Impedance and load losses at rated current on the rated voltage connection and on all taps, including excitation loss and excitation current.

    e. Dielectric low-frequency withstand, including applied-potential and induced-potential.

    f. Partial discharge tests in accordance with ANSI C57.12.01, or as follows:

        1) The transformer shall be subjected to an induced voltage of 1.5 times the rated voltage at a frequency between 100 Hz and 400 Hz.

        2) Partial discharge measurements shall be performed with a selected instrument operating at a frequency of 1.9 MHz.

        3) Partial discharge extinction level shall be reached at an induced voltage higher than 1.2 times rated voltage.

        4) Partial discharge extinction level shall be considered to have been reached when the reading at 1.9 MHz is less than 10 microvolts or 13 picocoulombs.

D. Interphase Transformers

1. The following tests shall be performed on the interphase transformers in accordance with IEEE C57.12.91:

    a. Resistance measurement.

    b. Reactance excitation current and core loss measurements.

    c. Calculated DC loss at rated load.

    d. Insulation resistance test between windings and core.

    e. Applied voltage or Hi-pot test at the test voltage level of the rectifier.

E. Rectifiers

1. Design tests shall be performed on one rectifier, including the diode protection, monitoring and alarm functions, in accordance with IEEE 1653.2. Design tests shall be performed on the negative disconnect switch in accordance with ANSI C37.45.

    a. Diode types for use in the rectifier shall be fully tested in accordance with JESD282B.01.

        1) Included in these reports shall be two copies of the registration format outlined in JESD282B.01.

        2) The test results shall be certified by both the diode manufacturer and the rectifier manufacturer.

    b. End points for tests shall be well beyond maximum values to be expected under any loading conditions. Diodes shall be dated as specified using the four-digit code and shall meet or exceed Class B requirements in accordance with JESD282B.01.

    c. Rectifier-type instruments shall not be used in making any of the specified tests. Limiting or end point values for reverse current or forward voltage drop shall be at least twice the maximum rated values listed in the registration format. Each curve shall be clearly labeled to show test conditions and shall show actual data points.

2. The following production tests indicated in IEEE 1653.2 shall be performed on rectifier units:

    a. Dielectric strength test.

    b. Rated voltage test.

    c. Rated current test, including current imbalance:

        1) Between phases.

        2) Between each diode in each phase.

    d. Diode protective, monitoring and alarm functions.

e. Applicable tests identified as Production Tests in IEEE C37.41 for the negative disconnect switch.

2.06 SYSTEM FACTORY FUNCTIONAL TESTING

A. Refer to Section 34 21 75, Traction Power Facility System Factory Functional Testing for requirements.

PART 3 – EXECUTION

3.01 FIELD ACCEPTANCE TESTING

A. Refer to Section 34 21 80, Traction Power System Field Acceptance Testing for requirements.

B. Provide recommended field test procedures.

END OF SECTION 34 21 22

SECTION 34 21 25

DC SWITCHGEAR

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. General requirements

B. Operating requirements

C. Ratings

D. Housing

E. Structure

F. Circuit breakers

G. Power buses and bus connections

H. Equipment protection

I. Instrumentation

J. 125 V DC control power

K. 120 V AC control power

L. Cable terminations

M. Negative enclosure

N. DC switchgear accessories

O. Factory testing

P. Traction power facility system factory functional testing

Q. Field acceptance testing

1.02 RELATED SECTIONS

Refer to the following Sections for requirements:

A. Section 01 33 00 Submittal Procedures

B. Section 01 33 23 Shop Drawings, Product Data, and Samples

C. Section 01 45 24 Testing Program Requirements

D. Section 01 78 23 Operation and Maintenance Data

E. Section 01 78 44 Spare Parts and Maintenance Materials

F. Section 34 21 01 General Requirements for the Traction Power System

G. Section 34 21 05 Prefabricated AC and DC Equipment Houses

H. Section 34 21 07 Prefabricated Portable Substations

I. Section 34 21 11 Multi-Function Protection Relay Equipment

J. Section 34 21 35 Emergency and Transfer Trip System

K. Section 34 21 40 DC Control Power System

L. Section 34 21 50 Common Materials and Methods for Traction Power

M. Section 34 21 75 Traction Power Facility System Factory Functional Testing

N. Section 34 21 80 Traction Power System Field Acceptance Testing

O. Section 34 22 23 Traction Power Cables

1.03 MEASUREMENT AND PAYMENT

1. General: DC switchgear will be measured for payment for each unit that is tested and furnished in accordance with the Contract Specifications.

2. Payment: DC switchgear will be paid for at the Contract unit price for each unit as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE C37.13 Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures

2. IEEE C37.14 Standard for DC (3200 V and below) Power Circuit Breakers Used in Enclosures

3. IEEE C37.20.1 Standard for Metal-Enclosed Low-Voltage (1000 Vac and below, 3200 Vdc and below) Power Circuit Breaker Switchgear

4. IEEE C37.90.1 Standard for Surge Withstand Capability (SWC) for Relays and Relay Systems Associated with Electric Power Apparatus

5. IEEE C37.23 Standard for Metal-Enclosed Bus

6. IEEE 1015 Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems

B. National Electrical Manufacturers Association (NEMA):

1. NEMA CC 1 Electric Power Connection for Substations
2. NEMA ICS 1 Industrial Controls and Systems General Requirements
3. NEMA ICS 2 Industrial Control and Systems Controllers, Contactors and Overload Relays Rated 600 Volts
4. NEMA ICS 6 Industrial Controls and Systems Enclosures
5. NEMA C37.51 Switchgear-Metal Enclosed Low-Voltage AC Power Circuit Breaker Switchgear Assemblies-Conformance Test Procedures

C. National Fire Protection Agency (NFPA):

1. NFPA 70 National Electric Code (NEC)
2. NFPA 101 Life Safety Code

D. Underwriters Laboratories Inc. (UL):

1. UL 857 Standards for Safety Busways
2. UL 1558 Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear
3. UL 1066 Standard for Low Voltage AC and DC Power Circuit Breakers Used in Enclosures

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures and Section 01 33 23, Shop Drawings, Product Data, and Samples for submittal requirements and procedures.

B. Submit the following:

1. Shop Drawings including equipment layouts, elevation views, circuit breaker control schematics, and interface details with the emergency and transfer trip system (ETTS), the structure ground relay, and the control and annunciator panel C02.
2. Product data for the DC switchgear and associated devices, such as relays and communication modules.
3. Test plan and procedures for factory testing.

4. Test report for factory testing.

5. Operations and Maintenance Manuals: Provide in accordance with Contract Specifications Section 01 78 23, Operation and Maintenance Data.

1.06 QUALITY ASSURANCE AND SUPPLIER QUALIFICATIONS

A. Electrical components, devices, and accessories shall be listed and labeled in conformance with NFPA 70, Article 100.

B. The manufacturer of the DC switchgear assembly shall have a minimum of five years of successful and proven design and manufacturing experience in the transit industry, providing equipment similar to the one to be furnished under this Contract.

C. The manufacturer of the 1200 V DC circuit breaker shall have a minimum of five years of successful and proven design and manufacturing experience in the transit industry, providing equipment similar to the one to be furnished under this Contract. The 1200 V DC circuit breaker shall be a standard product of the respective manufacturer.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Equipment shall be weatherproofed for shipment. Connection openings shall be closed to prevent entrance of foreign material during shipment and storage.

B. Equipment shall be handled and stored in conformance with manufacturer’s instructions. One copy of these instructions shall be included with the equipment at time of shipment.

1.08 SPARE PARTS, TEST EQUIPMENT, AND TOOLS

A. Mandatory Spare Parts: Furnish the following mandatory spare parts, test equipment and tools required to maintain and operate the traction power facility in accordance with the requirements of the Contract Specifications Section 01 78 44, Spare Parts and Maintenance Material.

1. One main breaker assembly per five facilities delivered.

2. Three feeder breaker assemblies per five facilities delivered.

B. Recommended Spare Parts: Provide a recommended list of spare parts, tools, and test equipment in accordance with the requirements of the Contract Specifications Section 34 21 01, General Requirements for the Traction Power System.

PART 2 – PRODUCTS

2.01 GENERAL REQUIREMENTS

A. System Description: The DC switchgear shall be suitable for installation and operation installed in traction power substations, gap breaker stations, and portable substations to provide DC power distribution, selective fault protection and contact rail isolation capabilities, as follows:

1. In typical traction power substations with two transformer-rectifier units, a double-ended 1200 V DC switchgear assembly shall receive power from the two traction rectifiers and distribute it to the contact rails through a sectionalizing scheme as indicated.

2. In gap breaker stations, the DC switchgear shall be used to provide sectionalizing flexibility and selective contact rail system isolation capability, such as at crossovers, pocket tracks, and turnouts.

3. In portable traction power substations with one transformer-rectifier unit, 1200 V DC switchgear shall receive power from a traction rectifier and distribute it to the contact rails through a sectionalizing scheme as indicated. Portable substation DC switchgear trailers may also be used as temporary gap breaker stations to provide sectionalizing flexibility similar to the gap breaker stations.

B. The DC switchgear shall be designed and fabricated in accordance with IEEE C37.14, IEEE C37.16, and IEEE C37.20.1.

C. The switchgear assemblies shall be of the metal-enclosed indoor type and shall include circuit breakers, positive buses, bus connections, protective relaying, negative enclosure, and other equipment and devices as indicated.

2.02 OPERATING REQUIREMENTS

A. DC circuit breakers shall be provided with both local and remote control and status monitoring.

B. Unless otherwise indicated, the DC circuit breakers shall be normally closed, supplying continuous power to the contact rails.

C. DC feeder breakers in traction power facilities shall also be controlled by the ETTS.

2.03 RATINGS

A. Unless otherwise indicated, the DC facilities shall be in accordance with IEEE C37.20.1, and shall have the following minimum ratings:

1. Rated Maximum Operating Voltage: 1200 V DC
2. Rated Main Bus Continuous Current: 8000 A
3. Rated Feeder Bus Continuous Current: As indicated

B. DC circuit breakers shall comply with IEEE C37.16 (Table 12) and IEEE C37.14, and shall have the following minimum ratings:

1. Rated Breaker Continuous Current:	As indicated
2. Rated Control Voltage:	125 V DC
3. Short-Circuit Current Ratings:	135 kA peak 80 kA steady state per IEEE C37.16
4. DC withstand voltage, one minute:	6.8 kV RMS
5. Basic Insulation Level (BIL):	12 kV peak
6. Rated Maximum Voltage:	1200 V DC

2.04 HOUSING

A. The switchgear shall be indoor type conforming to the applicable sections of IEEE C37.20.1.

B. The switchgear assemblies shall be housed in a prefabricated modular DC equipment house, specified in Section 34 21 05, Prefabricated AC and DC Equipment Houses, a prefabricated modular DC equipment house, specified in Section 34 21 07, Prefabricated Portable Substations, a CMU building, or within a passenger station equipment room.

2.05 STRUCTURE

A. The switchgear assemblies shall be of the metal-enclosed type and shall form a line-up of freestanding cubicles. Each cubicle shall consist of compartments to house the circuit breakers, bus bar, cables, relays and devices, as required. Each freestanding cubicle enclosure shall be electrically insulated from adjacent cubicles. Each DC feeder breaker cubicle shall be provided with removable links so that under normal operation they are electrically connected. The connection shall be designed such that when enclosure GROUNDED or ALIVE condition is detected, the connecting links by their selective manual removal will allow isolation of the problem enclosure.

B. Each cubicle shall be of a rigid, self-supporting and self-contained electrically welded or bolted steel structure enclosing the sides and top, except openings for specific purposes. The structure shall support equipment under normal and short-circuit conditions.

C. Panels comprising the switchgear enclosure, including the doors, shall be constructed of sheet steel of thickness not less than No. 11 gauge.

D. Compartments shall be isolated from one another by barriers of not less than No. 11 gauge sheet steel. Other covers, barriers, and panels shall be of sheet steel having thickness not less than No. 14 gauge.

E. Each cubicle shall have front-hinged doors with or without rear-hinged doors. Front door mounted on the breaker assembly is acceptable, provided it meets safety and specifications requirements. Rear-hinged doors, if provided, shall have provisions for locking and shall be removable without tools. Each compartment shall have a separate hinged door so that servicing one compartment will not expose circuits in adjacent compartments:

1. The doors shall support flush and semi-flush mounted devices and not distort from a plane surface in any position with all devices mounted. Doors shall be supported by means of concealed hinges, and structural reinforcing shall be used as needed to prevent sagging.

2. Each hinged door shall have a handle and a mechanical three-point vibration-proof latch for holding it in a closed position.

3. Each cubicle door shall be provided with a stop to hold the door in the open position, so that devices mounted on this door will not touch the devices mounted on adjacent doors.

4. Front door of each circuit breaker compartment shall interlock with the circuit breaker controls, so that door opening trips the breaker.

5. At the traction power and portable substations, a key-interlock shall be provided between the DC main circuit breaker and the corresponding negative return disconnect switch in the rectifier, so that the disconnect switch can be operated only when the main breaker is in the open position.

6. Provide infrared compatible viewing window on each circuit breaker feeder compartment door to allow viewing and infrared monitoring of feeder bus cable connections.

F. The circuit breaker compartment shall be designed so that the removable element, the circuit breaker proper, may be drawn in and out of its housing on guide ways, and make connections to the positive bus and auxiliary circuits by means of self-aligning, self-coupling primary and secondary disconnecting devices. Secondary disconnecting devices by means of plug connectors are acceptable provided each connector has a different pin arrangement. Cables used with the connectors shall be harnessed properly to prevent any damage due to the movement of the breaker assembly.

G. Breaker compartment surfaces, and portions thereof, exposed to arcs or ionized gases shall be lined with flame-resistant, insulating barrier material.

H. Bus compartments shall be of rigid framework and shall include, but not be limited to, positive bus work, splice plates, cable terminal connectors, and bus and cable supports.

I. For cleaning and inspection, removable cover plates with lifting handles for bus compartment openings shall be provided to provide access to the bus and cable connections with cables in place. Plates shall be less than 18 by 24 inches in size, have no sharp edges, and weigh less than 20 lbs. each.

J. The switchgear enclosure, if required by test design, shall contain louvers as defined by IEEE C37.20.1 to provide ventilation and air-cooling of the components. If ventilation is required, intake openings shall be located not less than six inches above the floor where they do not allow entry of debris or dirt. Adequate provisions shall be made for release of gases from the breaker cubicles by stacks, chimneys, louvered vent openings, and shall be arranged in such a way that hot gases or other materials cannot be discharged in a manner hazardous to personnel, or detrimental to equipment.

K. Items requiring inspection and maintenance shall be accessible from the front or rear of the switchgear lineup and be located within 72 inches from the floor.

2.06 CIRCUIT BREAKERS

A. General:

1. The switchgear assemblies shall include air type DC circuit breakers.

2. The circuit breaker shall be metal-enclosed, single-pole, high-speed type rated as specified herein, and in accordance with IEEE C37.14 and IEEE C37.16. The main switching and interrupting element of the circuit breaker shall be of the removable type, mounted on a wheeled truck together with its operating mechanism, controls, and closing and tripping devices.

3. The circuit breaker control circuits and its operating mechanism shall be rated for power supply from a 125 V DC source.

4. The transient voltage surge introduced by the circuit breakers during interruption shall not exceed the one-minute DC withstand voltage rating of the switchgear.

5. The circuit breaker shall have a cold cathode arc chute for the main contacts, consisting of arc chambers and splitter plates for confining and extinguishing electrical arcs.

6. The circuit breaker shall be equipped with a blowout device or a similar feature to help extinguish low-current arcs, as defined and tested in accordance with IEEE C37.14.

7. Contact surfaces of the moving and stationary main contact members shall be silver, non-welding silver alloy or equivalent with the characteristics of high conductivity and necessary arc-resistant properties.

8. Removable circuit breaker elements of the same type and rating shall be physically and electrically interchangeable. Removable breaker elements not of the same type or ratings shall not be interchangeable.

B. Breaker Positions: The removable element of the circuit breaker shall have three positions inside the cubicle, referred to as CONNECTED, TEST, and DISCONNECTED positions. A fully interlocked, manually operated racking mechanism shall be furnished to move the mobile breaker assembly to and from the CONNECTED, TEST, and DISCONNECTED positions:

1. In the CONNECTED position, both the primary and secondary disconnecting devices shall be in full contact.

2. In the TEST position, the primary disconnecting devices shall be open and separated by sufficient clearance to prevent arcing, with access to the stationary contacts blocked by safety shutters. However, the secondary disconnecting devices shall be in full contact.

3. In the DISCONNECTED position, both primary and secondary disconnecting devices shall be completely disconnected.

4. If an umbilical cord is used, there shall be interlocks to prevent removing the breaker from the cubicle while the secondary is connected.

5. The circuit breaker shall be held securely in place in the housing when the removable element is in the CONNECTED or TEST positions.

6. In the TEST position, there shall be an interlock that ensures the secondary connection stays connected in order to move the breaker back into the CONNECTED position. If the secondary connection is disconnected, the circuit breaker cannot be racked in.

C. Breaker Controls:

1. A 143 LOCAL/REMOTE switch shall be provided on the breaker cell. When the switch is in the local position, CLOSE commands from the C02 panel or OCC shall be blocked, but TRIP commands shall remain active. Additionally, when the switch is in the local position, local commands shall have a few seconds delay, providing time for personnel to move away from the breaker.

2. A test switch shall be provided on the front of each circuit breaker that shall allow electrical closing with the breaker only in the TEST position, without the application of the MPR auto-reclose function. Operation of the breaker's TRIP command from the C02 panel or from the OCC shall not be allowed when the breaker is in the TEST position.

3. Manual local control of the breaker while in the CONNECTED position shall be from the control switch installed on the control and annunciator (C02) panel of the traction power facility.

4. Each circuit breaker shall be provided with backup mechanical means for tripping when it's in the TEST and CONNECTED positions. This function shall be available with the breaker's compartment door closed.

5. Remote control of all circuit breakers shall be provided through the SCADA system:

   a. Controls of all circuit breakers shall be designed so that the breaker can be:

      1) Tripped by remote command at all times, and

2) Closed by remote command only when the LOCAL-REMOTE selector switch is in the REMOTE position.

b. The interface between breaker controls and the SCADA system shall be at the interface terminal cabinet as indicated.

6. A minimum of eight electrically separate reversible auxiliary breaker contacts shall be provided as spares, in addition to those required for the circuit breaker control circuit.

7. All auxiliary breaker contacts shall be operated by the breaker mechanism in both the CONNECTED and TEST positions. Circuit breaker OPEN/CLOSED status indications and CONNECTED/TEST/DISCONNECTED position indications updates shall be available on the C02 panel and remotely available at the OCC. Auxiliary contacts shall be wired to terminal blocks and labeled properly. Mechanically operated contacts (MOC) for breaker status or position indication shall not be used.

8. A closed circuit breaker shall remain closed and not trip in the event of a loss of the 125 V DC control power. This feature shall be inherent in the circuit breaker mechanism as delivered from the factory.

9. The circuit breaker shall be furnished with a minimum four-digit operation counter to record tripping operations, with no provisions for resetting the counter to zero.

10. Manual local control shall be provided when the LOCAL-REMOTE selector switch is in the LOCAL position and the DC breaker is in the CONNECTED position.

D. Operating Mechanism:

1. Each circuit breaker shall be operated by means of either a solenoid (magnetic or electric), or a motor-operated, stored-energy mechanism; and shall have a latch for positive quick-make and quick-break operations with currents up to the short-time current rating of the breaker. The operating mechanism shall ensure full contact pressure until time of opening. The circuit breaker shall have mechanically held closed mechanism only and shall not open if 125 V DC control power is removed.

2. Each circuit breaker shall have a shunt-tripping device for tripping the breaker by a 125 V DC electrical control signal.

3. Breakers shall be electrically and mechanically trip-free, and shall have control circuits connected in a manner to make the mechanism anti-pumping.

4. Means shall be provided to locally close the circuit breakers in the event of emergency or for testing purposes. The local close shall also function if the control panel C02 PLC, C04 Network switch, or a fiber optic link is inoperable.

5. The circuit breakers shall be electrically operated in normal circumstances, using the 125 V DC control power system of the traction power facility or portable substation. The operating mechanism shall successfully close the breaker over a voltage range of 100 to 140 V DC and trip the breaker over a voltage range of 70 to 140 V DC.

6. Solenoid-type closing mechanisms, if used, shall be connected so that control voltage is removed from the closing coil after a preset time. In the event the breaker does not close, or the control circuit is not opened, a trip sequence shall be initiated to open the closing control circuit and restore closing sequence relays to their normal status.

E. Withdrawal Mechanism:

1. Each switchgear cubicle shall have a cranking device for moving the removable circuit breaker element to the CONNECTED, TEST, or DISCONNECTED positions with the door closed. If charging motor is used, a switch shall be provided to disconnect the charging motor circuit during cranking.

2. Guideways shall be provided to ensure proper alignment of the circuit breaker during insertion or withdrawal. Breaker insertion and withdrawal shall be effortless and shall be within the capabilities of an average person.

3. The wheels of the breaker assembly shall be durable plastic or provided with rubber rims to prevent indenting or scratching the floor surface when the breaker assembly is withdrawn from the cubicle or moved around the substation house.

F. Electrical and Mechanical Interlocks: Circuit breakers shall be furnished at a minimum with the following electrical and mechanical interlocks.

1. Positive acting mechanical interlocks shall be provided on each unit to:

   a. Prevent a closed circuit breaker from being moved in or out of the CONNECTED position,

   b. Discharge the stored energy springs prior to circuit breaker removal, and

   c. Prevent a closed circuit breaker from being moved from the TEST to the CONNECTED position.

2. Positive stops shall be provided to prevent over-travel of the circuit breaker when it is being moved into the CONNECTED or TEST positions.

   A visual indicator shall be provided to show when the circuit breaker is in the CONNECTED or TEST position.

3. Electrical closing of the circuit breaker within the compartment shall be prevented except when the removable element is locked in place for the CONNECTED or TEST positions.

4. If the front door of the cubicle is still open, an interlock shall be provided to prevent the circuit breaker from being racked into the CONNECTED position.

5. If the circuit breaker is in the CONNECTED position, an interlock shall be provided to prevent the door from being opened.

6. If the springs are not fully charged, an interlock shall be provided to prevent the circuit breaker from closing.

G. Disconnecting Devices:

1. Each circuit breaker shall be equipped with primary and secondary disconnecting devices and associated contacts, to make or break the power and control circuits, respectively, depending on the position of the breaker's removable element. The disconnecting devices shall be designed and mounted to maintain the correct alignment between their stationary and moving parts during insertion and withdrawal of the removable breaker element.

2. Each circuit breaker's primary disconnecting devices shall comprise of heavy-duty, self-aligning, silver-plated copper disconnect fingers that engage with the load-side stationary parts of the contacts. Access to the stationary part of the primary disconnecting devices shall be prevented when the circuit breaker is in the CONNECTED, TEST and DISCONNECTED positions. To achieve this, shutters shall be provided to automatically cover the stationary contacts when the breaker is withdrawn to the TEST or DISCONNECTED positions.

3. The secondary disconnecting devices shall have silver-plated copper contacts and shall be of a design that automatically or manually connects or disconnects the control circuits of the circuit breaker, when the circuit breaker is inserted into or removed from its compartment. The secondary disconnecting devices shall be without tendency of misalignment and shall not be prone to warping or loss of contact pressure due to repeated withdrawals of the breaker from its cubicle or during accidental knocks during routine maintenance. The secondary disconnecting devices shall be engaged in both the CONNECTED AND TEST positions and disengaged in the DISCONNECTED position.

H. Breaker Status Indications:

1. OPEN and CLOSED status of the breakers shall be shown by green and red LED indication lights, respectively. The indication lights shall be mounted on the front door of the circuit breaker cubicle, and on the control and annunciator panel C02, as indicated.

2. The red 'BREAKER CLOSED' lights shall be connected to monitor the continuity of a shunt trip circuit.

3. An amber LED light shall be provided to indicate if the breaker is in the CONNECTED position. The amber LED shall be located together with the red and green LEDs mounted on the front door of the breaker cubicle.

4. A mechanical status indicator, visible when the door is closed, shall be provided as a backup indication of the OPEN or CLOSED status of the circuit breaker.

5. A mechanical flag or position indicator shall be provided to show whether the circuit breaker is in the CONNECTED, TEST or DISCONNECTED position. The position indicator shall be visible when the circuit breaker compartment door is closed.

6. The status of the charging mechanism, if a stored energy mechanism is used, shall be indicated on the front door panel, via visual mechanical indicator. Provide additional auxiliary contacts for possible future remote indication.

7. Provide separate truck-operated switch interlock contacts to indicate breaker CONNECTED AND TEST positions.

8. Provide truck-operated switch interlock to block operation of the DC feeder breaker from the C02 control and annunciator panel when the breaker is in the TEST position.

2.07 POWER BUSES AND BUS CONNECTIONS

A. Buses and bus connections shall be as specified in the applicable portions of Section 34 21 50, Common Materials and Methods for Traction Power.

B. The DC buses shall be made of bare copper and have sufficient cross section to carry the continuous rated current of the associated circuit breakers as specified, without exceeding the allowable temperature rise indicated in IEEE C37.20.1.

C. The buses shall be supported by non-tracking, non-hygroscopic insulators and insulated supports and bushings, of sufficient strength and bracing to withstand, without damage or permanent distortion, the forces produced by the rated short-circuit currents of the circuit breakers.

D. Provide electrically insulating barriers shielding DC switchgear buses while DC feeder compartment rear doors are open. Barriers shall inhibit accidental contact with energized buses from above and from the rear.

2.08 EQUIPMENT PROTECTION

A. Relaying, metering, and indicating devices for the DC switchgear shall be provided as specified in Section 34 21 35, Emergency and Transfer Trip System, Section 34 21 11, Multi-Function Protection Relay Equipment, and Section 34 21 50, Common Materials and Methods for Traction Power, as indicated.

B. Overcurrent Trip Device (Device 176): Each DC feeder circuit breaker shall be provided with a direct-acting, instantaneous forward overcurrent trip device. The trip device shall be adjustable between 100 and 400 percent of the circuit breaker continuous current rating and shall be provided with an auxiliary contact that closes only when the instantaneous over-current trip device 176 is activated.

C. Multi-Function Protection Relay (MPR): DC feeder circuit breakers shall be equipped with electronic multi-function protection relays providing for instantaneous, inverse-time, low level fault, reverse, and rate of rise overcurrent functions, as specified in Section 34 21 11, Multi-Function Protection Relay Equipment.

D. Load Measuring and Automatic Reclosing System: The MPR shall provide load measuring and automatic breaker re-closing capability, designed to prevent feeder breakers from closing on a short-circuit fault in the contact rail system. Features and logic sequence for the load-measuring and auto-reclosing system shall be as specified in Section 34 21 11, Multi-Function Protection Relay Equipment.

E. Provide the load-measuring and auto-reclosing system and components, including hardware such as DC contactors, load-measuring resistors and wiring, as required to provide a complete and functional system. Control power for the MPR shall be from a separate circuit, independent from the control power of other circuit breaker functions and devices.

F. Track Potential Detection (Dev 127): Each DC feeder circuit breaker shall be provided with an undervoltage detection (Dev 127), which shall be implemented as a function of the MPR. The undervoltage condition, used to indicate a de-energized contact rail section, shall be annunciated remotely from the MPR as indicated.

G. Directional Overcurrent Relay (Device 132): DC circuit breakers in gap breaker stations and DC main circuit breakers in traction power substations shall be provided with directional overcurrent protection. The input signal to the directional overcurrent relay shall be from an isolation transducer, which in turn shall be connected to a current shunt, as indicated:

1. In gap breaker stations with common bus configuration, provide overcurrent tripping only for the current in the forward (away from the bus) direction. Device 132 shall be a function of the MPR.

2. In traction power substations and portable substations, the DC main breaker directional overcurrent relay shall be used to detect short circuits or positive bus to ground faults in the traction rectifier, and prevent back-feeding the fault from the contact rail system by tripping the main breaker upon detection of reverse current flow. The relay's current setting shall be as low as practically possible.

H. Enclosure Alive/Grounded Relaying (Device 164A/164G): Insulate the DC main breaker, DC feeder breaker, and rectifier cubicles from each other, and connect each to the station ground through a high-resistance ground relay (Device 164A/164G) as indicated. Provide a separate 164A/164G relay for each rectifier, for each DC main circuit breaker, and for the DC feeder circuit breakers' line-up. The relay shall detect any part of the enclosure that may become grounded or energized in the event of a fault between the enclosure and any of the current carrying components. Each relay shall be self-monitoring to ensure the integrity of its functions and shall be provided with a mechanical target to indicate alarmed and reset positions:

1. Provide Device 164G enclosure alive/grounded relays with contacts to initiate local and remote alarms if the monitored enclosure comes in contact with either ground or the negative side of the 1000 V DC system. Fabricate enclosure from fiberglass or other non-conductive material.

2. Provide Device 164A enclosure alive/grounded relay with contacts to initiate local and remote alarms and to trip and lock-out the substation circuit breakers through lockout relays, Devices 186 and 286. At traction power facilities, activation of the 186 lockout relay shall initiate transfer tripping of adjacent traction power substations or gap breaker stations associated DC feeder circuit breaker. At traction power facilities, if a rectifier enclosure or DC main circuit breaker enclosure is alive, then the associated Device 164A shall activate and trip the Device 286 lockout relay that trips the associated DC main circuit breaker, the 34.5kV main circuit breaker and the tie circuit breaker to isolate the affected rectifier, or only trip the associated DC main circuit breaker and keep the other rectifier, DC main circuit breaker and DC feeder circuit breakers switchgear in service. For portable substations, if a rectifier enclosure or DC main circuit breaker enclosure is alive, then the associated Device 164A shall activate and trip the Device 286 lockout relay that trips the associated DC main circuit breaker and AC vacuum fault interrupter.

3. A local indication for structure GROUNDED or ALIVE shall be provided for each Device 164 relay. The indication shall consist of colored indicating LEDs with mounting arrangement and shall be submitted to the Engineer. The indications shall be as follows:

   a. Amber LED to indicate grounded structure.

   b. Red LED to indicate alive or hot structure.

4. Test switches shall be provided to simulate GROUNDED and ALIVE conditions.

5. Install Device 164A/164G relay for the DC feeder breaker switchgear line-up in a wall mounted test cabinet, allowing selective isolation of the frames of individual DC switchgear cubicles for troubleshooting purposes, as indicated on the Contract Drawings.

6. Provide a pushbutton switch in each DC feeder breaker front door to check the integrity of the transfer tripping scheme. The pushbutton switch shall be protected or guarded to prevent accidental operation.

I. ETTS: The DC feeder circuit breakers shall be incorporated in an integrated emergency tripping and transfer tripping system based on fiber-optic communications between traction power facilities, as described in Section 34 21 35, Emergency and Transfer Trip System, and as indicated on the Contract Drawings.

2.09 INSTRUMENTATION

A. Instruments for measuring currents and voltages at the 1000 V DC shall receive their inputs from isolating transducers, that shall be furnished and mounted within the bus compartment of the switchgear assemblies.

B. Proper insulation for meters and instruments shall be provided to assure safe operation for maintenance personnel. Wiring and terminal blocks in the DC switchgear that are exposed to the 1000 V DC potential shall have 2 kV insulation and shall be equipped with warning signs and tags. Wires with 2 kV insulation shall be as specified in Section 34 22 23, Traction Power Cables. Connections to 1000 V potential shall be fused.

C. Isolation transducers associated with MPRs shall be powered from the associated MPR controller, using any appropriate control voltage. The power supply to the isolation transducers operating on circuit breakers without MPR units shall be 125 V DC.

D. Instruments and isolation transducers shall be as specified in Section 34 21 50, Common Materials and Methods for Traction Power.

2.10 125 V DC CONTROL POWER

A. The 125 V DC station battery system shall be used for closing and tripping functions of the circuit breakers, and for energizing control and protection devices in the DC switchgear. The 125 V DC battery system shall conform to Section 34 21 40, DC Control Power System.

B. Control power cables supplying 125 V DC power to the switchgear shall be No.10 AWG or larger, shall have minimum 600 V rated insulation, shall be run in a protective raceway the full length of each switchgear assembly, and shall be tapped at each cubicle served via terminal blocks.

C. Mount 125 V DC control circuits within each DC switchgear cubicle on insulating boards within switchgear and control cubicles.

D. Two separate control power circuits shall be provided in the DC switchgear assembly, one used for circuit breaker control and operation, the other for power supply to relays and transducers.

E. Control power circuits, including branches, shall be protected by molded-case, thermal-magnetic circuit breakers.

F. Provide contacts to implement separate Device 27 undervoltage alarm monitoring for sub-circuits of DC switchgear controls to aid troubleshooting.

2.11 120 V AC CONTROL POWER

A. A 120 V AC, 60 Hz control power shall be supplied via No. 12 AWG or larger two-wire cable with minimum 600-V insulation, for use by devices such as heaters, fans, lights, and receptacles.

B. Main AC power supply circuits shall be connected through isolation transformers providing 1500 V DC isolation.

C. The AC control power cable shall:

1. Extend for the full length of each switchgear assembly.

2. Be terminated on a terminal block for connection to an external power supply.

3. Be tapped to the circuit breakers, protecting the circuits for heaters, fans, lights and receptacles. Lighting circuits shall be independent of other circuits.

2.12 CABLE TERMINATIONS

A. Provisions shall be made in the DC circuit breaker cubicles to accommodate the required number of 2.4 kV rated, 750 kcmil sized copper cables for each termination as indicated.

B. Ample space and contact surface shall be provided for pulling and terminating the cables.

C. Cable connectors for the 750 kcmil power cables shall be NEMA two-hole type.

D. Low voltage terminations shall be as indicated in Section 34 21 50, Common Materials and Methods for Traction Power.

2.13 NEGATIVE ENCLOSURE

A. The negative enclosure shall be an indoor type and shall be built in coordination with and as part of the DC switchgear assemblies. The enclosure shall have minimum dimensions as required for ease of installation of the specified number of 750 kcmil power cables terminated at the negative bus.

B. The negative enclosure shall include the negative bus, bus connections, bus supports, and termination hardware for the 750 kcmil power cables as indicated.

C. Do not route DC positive bus through negative enclosures.

2.14 DC SWITCHGEAR ACCESSORIES.

A. Switchgear maintenance accessories shall be furnished at each traction power facility or portable substation, including but not limited to the following:

1. Handling device for removing, replacing and transporting the DC circuit breakers for one-man operation, if required.

2. Removable lever for opening and closing the circuit breakers.

3. One set of test plugs for drawout relays and instruments.

4. One set of wrenches for the primary disconnecting devices of the circuit breaker, if required.

5. One set of fuse tongs or hook sticks, depending on requirements.

6. Wall mounting test cabinet for operating, testing, and inspecting the circuit breakers when removed from their compartments.

7. One set of test jumpers for connecting breaker units to the test cabinet.

8. At a minimum, 12-foot long multi-conductor test cable with a secondary disconnect connector on both ends, to permit operating a circuit breaker when withdrawn from its compartment. This cable will be required to connect the control circuits of the withdrawn breaker and to operate the breaker without use of the test cabinet.

9. One secondary contacts shorting device, used for meggering the secondary circuits.

10. Gauges needed to set mechanical clearances on the DC circuit breaker.

11. Any proprietary tools required for switchgear maintenance.

2.15 FACTORY TESTING

A. General: Factory testing for the DC switchgear, including testing plan, procedures and documentation shall be in accordance with Section 01 45 24, Testing Program Requirements.

B. Design Tests: The following design tests shall be performed on one DC circuit breaker and one DC switchgear assembly:

1. Applicable tests identified as Design Tests in IEEE C37.14 shall be performed on one DC circuit breaker.

2. Applicable tests identified as Design Tests in IEEE C37.20.1 shall be performed on one DC switchgear assembly.

3. Mechanical endurance test: Withdraw and insert one completely assembled DC circuit breaker from and to its cubicle 20 times within 90 minutes and inspect the breaker assembly for any misalignment. Report and repair any defects incurred as a result of this test.

4. Load measuring and auto-reclosing functions: Confirm the proper operation of the circuit breaker with the complete load measuring and auto-reclosing system, including MPR-based logic, contactor, and circuit breaker control circuits.

C. Production Tests: The following production tests shall be performed on all DC circuit breakers and DC switchgear assemblies:

1. Applicable tests identified as production tests in IEEE C37.14 shall be performed on all DC circuit breakers.

2. Applicable tests identified as production tests in IEEE C37.20.1 shall be performed on all DC switchgear assemblies.

3. Load measuring and auto-reclosing functions.

2.16 TRACTION POWER FACILITY SYSTEM FACTORY FUNCTIONAL TESTING

A. Refer to Section 34 21 75, Traction Power Facility System Factory Functional Testing for requirements.

PART 3 – EXECUTION

3.01 TRACTION POWER SYSTEM FIELD ACCEPTANCE TESTING

A. Refer to Section 34 21 80, Traction Power System Field Acceptance Testing for requirements.

END OF SECTION 34 21 25

SECTION 34 21 27

LIQUID IMMERSED TYPE AUXILIARY POWER TRANSFORMERS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Self-cooled, three-phase, two-winding liquid immersed medium voltage auxiliary power transformers (34.5 kV - 480/277 V), associated devices and appurtenances.

1.02 RELATED SECTIONS

A. Refer to the following Sections for requirements:

1. Section 01 20 00 Price and Payment Procedures
2. Section 01 33 00 Submittal Procedures
3. Section 01 33 23 Shop Drawings, Product Data, and Samples
4. Section 01 43 00 Quality Assurance
5. Section 01 45 00 Quality Control
6. Section 01 45 24 Testing Program Requirements
7. Section 01 74 14 Cleaning
8. Section 01 77 00 Closeout Procedures
9. Section 01 78 23 Operation and Maintenance Data
10. Section 01 78 39 Contract Record Documents
11. Section 01 78 44 Spare Parts and Maintenance Materials
12. Section 01 79 00 Demonstration and Training
13. Section 20 50 13 Raceway for Facility Services
14. Section 20 50 16 Underground Ductworks and Structures for Facility Services
15. Section 26 05 24 Low Voltage Wires and Cables
16. Section 26 05 29 Hangers, Supports, Seismic Protection and Sealants
17. Section 26 05 53 Identification Requirements
18. Section 34 21 01 General Requirements for the Traction Power Systems

19. Section 34 21 02 Design and Product Deliverable Requirements for the Traction Power System
20. Section 34 21 19 Separable Insulated Connector
21. Section 34 21 33 Traction Power Control, Monitoring and Display Panel
22. Section 34 21 50 Common Materials and Methods for Traction Power System
23. Section 34 21 60 Grounding and Bonding for Traction Power Facilities
24. Section 34 21 70 Traction Power Facilities Installation Requirements
25. Section 34 21 80 Traction Power System Field Acceptance Testing
26. Section 34 22 23 Traction Power Cables

1.03 MEASUREMENT AND PAYMENT

A. Liquid immersed type auxiliary power transformers will be measured for payment by the individual unit (each) for the locations indicated in the Bid Schedule of the Bid Form, installed in place, including associated devices and appurtenances.

B. Liquid immersed type auxiliary power transformer will be paid for at the indicated Contract unit price per each for the computed quantities as determined by the measurement method specified in Article 1.03A, herein.

1.04 REFERENCES

A. Activities shall be in accordance with following codes, standards, and specifications except as provided herein. Where requirements conflict with requirements specified herein or elsewhere in the Contract the more restrictive requirements shall apply.

B. American National Standards Institute (ANSI):

1. ANSI B.1.1 Unified Inch Screw Threads
2. ANSI/NEMA C2 National Electrical Safety Code
3. ANSI/NEMA C29.1 Test Methods for Electrical Power Insulators
4. ANSI/NEMA C39.1 Requirements for Electrical Analog Indicating Instruments
5. ANSI C57.12.70 Terminal Markings and Connections for Distribution and Power Transformers
6. ANSI Z 55.1 Gray Finishes for Industrial Apparatus of Equipment

C. American Society for Testing and Materials (ASTM):

1. ASTM D6871 Standard Specification for Natural (Vegetable Oil) Ester Fluids used in Electrical Apparatus

D. International Electrochemical Commission (IEC):

1. IEC 1203 Synthetic Organic Esters for Electrical Purposes - Guide for Maintenance of Transformer Esters in Equipment

E. California Electric Code (CEC)

F. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE 48 Standard for Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV Through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV
2. IEEE C37.2 Standard Electrical Power System Device Function Numbers, Acronyms, and Contact Designations
3. IEEE C37.90 Standards for Relays and Relay Systems Associated with Electric Power Apparatus
4. IEEE C57.12.00 Standard for General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
5. IEEE C57.12.34 Standard Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformer, 10 MVA and Smaller; High-Voltage, 34.5 kV Nominal System Voltage and Below; Low-Voltage, 15 kV Nominal System Voltage and Below
6. IEEE C57.12.80 Standard Terminology for Power and Distribution Transformers
7. IEEE C57.12.90 Standard Test Code for Liquid-Immersed Distribution, Power and Regulating Transformers
8. IEEE C57.91 Guide for Loading Mineral-Oil-Immersed Transformers and Step-Voltage Regulators
9. IEEE C57.98 Guide for Transformer Impulse Tests
10. IEEE 386 Standard for Separable Insulated Connector Systems for Power Distribution Systems Rated 2.5 kV through 35 kV
11. IEEE 519 IEEE Recommended Practices and Requirements for Harmonic Control in Electric Power System
12. IEEE 693 Recommended Practices for Seismic Design of Substations

G. National Electrical Manufacturers Association (NEMA):

1.	NEMA BU 1	Busways
2.	NEMA ICS 4	Application Guideline for Terminal Blocks
3.	NEMA ICS 6	Industrial Control and Systems: Enclosures
4.	NEMA TR1	Transformers, Regulators and Reactors
5.	NEMA WC 70/ ICEA S-95-658	Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy

H. National Fire Protection Association (NFPA):

1.	NFPA 70	National Electrical Code (NEC)
2.	NFPA 130	Standard for Fixed Guideway Transit and Passenger Rail Systems
3.	NFPA 101	Life Safety Code

I. Underwriters Laboratories (UL):

1.	UL 486 A and B	Wire Connectors

1.05 SUBMITTALS

A. Refer to the following Sections for additional requirements:

1.	Section 01 33 00	Submittal Procedures
2.	Section 01 33 23	Shop Drawings, Product Data and Samples
3.	Section 01 78 23	Operation and Maintenance Data
4.	Section 01 79 00	Demonstration and Training
5.	Section 34 21 01	General Requirements for the Traction Power System
6.	Section 34 21 02	Design and Product Deliverable Requirements for the Traction Power System
7.	Section 34 21 80	Traction Power System Field Acceptance Testing

B. Submit the following documents for equipment and materials specified herein and provided under the Contract for the auxiliary power transformers:

1. Product Data: Submit product data for the liquid immersed medium voltage auxiliary power transformers, enclosure, connectors, materials, special installation tools, and accessories. Product data shall include product description, bill of materials, and detailed technical specifications.

2. Shop Drawings to include but not limited to the following:

    a. Single line diagrams.

    b. Physical arrangement drawings and weights of equipment.

    c. Transformer bushing drawing.

    d. Unit wiring diagrams.

    e. Drawings showing space available for conduit entrance and for routing and training of cables. Available space shall take into consideration bending radius requirements of cables.

    f. Schematic diagrams.

    g. Setting diagrams and templates for anchoring in concrete.

    h. Interconnection diagrams for circuits having externally located instruments, controls, alarms or similar devices.

    i. Nameplate schedule.

    j. Component list.

    k. Ratings:

        1) KVA.

        2) Voltage.

        3) Continuous current.

        4) Basic insulation level.

        5) Resistance and impedance.

        6) Transformer efficiency at 100 percent, 75 percent, 50 percent, and 25 percent of the full load rating.

        7) Cable terminal sizes.

3. Seismic calculations to show compliance with the requirements of the Contract. Submittals shall be signed and sealed by a registered professional structural engineer licensed in the State of California.

4. Certificates from manufacturers verifying that equipment conforms to specified requirements.

5. Material safety data sheets.

6. Factory acceptance test documentation (e.g. procedures, data sheets, reports) per Section 34 21 80, Traction Power System Field Acceptance Testing.

7. Installation Manual and Drawings

    a. Installation manual shall include, but not limited to the following:

        1) A table of contents that shall identify pages of the manual by revision and date.

        2) Installation practices and procedures that the Contractor plans to use to accomplish the installation of the liquid immersed medium voltage auxiliary power transformers and shall be kept current at all times.

        3) A list of installation drawings by number, revision, title and approval status and a copy of each drawing reduced to B size (11 by 17 inches).

        4) Quality control procedures associated with the transportation and installation of the liquid immersed auxiliary power transformers.

        5) Installation verification procedures and data sheets.

        6) Staging and implementation plans.

8. Certification that exterior powder coating system is a two-step process that provides 5 mils minimum thick weather-resistant finish.

9. Certification from a CA factory-trained manufacturer's representative(s) that certifies the equipment has been installed, adjusted, and tested in accordance with the manufacturer's recommendations.

10. Installation verification and field functional test documentation (e.g. procedures, data sheets, reports) per Section 34 21 80, Traction Power System Field Acceptance Testing.

11. System integration test documentation (e.g. procedures, data sheets, reports) per Section 34 21 80, Traction Power System Field Acceptance Testing.

12. Spare parts list: Refer to Section 01 78 44, Spare Parts and Maintenance Materials for requirements.

13. O&M Manuals (System): Refer to Section 01 78 23, Operation and Maintenance Data for requirements.

14. Training materials: Refer to Section 01 79 00, Demonstration and Training for requirements.

15. Warranty certification.

1.06 QUALITY CONTROL, QUALITY ASSURANCE AND SUPPLIER QUALIFICATIONS

A. Refer to Section 34 21 01, General Requirements for the Traction Power System, and Section 34 21 70, Traction Power Facilities Installation Requirements, Article 1.06 for the requirements.

1.07 DELIVERY, STORAGE AND HANDLING

A. Refer to Section 34 21 70, Traction Power Facilities Installation Requirements, Article 1.06 for the requirements.

B. Equipment shall be weatherproofed for shipment. Connection openings shall be closed to prevent entrance of foreign material during shipment and storage.

C. Equipment shall be handled and stored in conformance with manufacturer's instructions. One copy of these instructions shall be included with the equipment at time of shipment.

1.08 GENERAL REQUIREMENTS FOR THE TRACTION POWER SYSTEM

A. Refer to Section 34 21 01, General Requirements for the Traction Power System, for the requirements.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

A. The liquid immersed medium voltage auxiliary power transformers shall be manufactured by any of the following:

1. Square D Company
2. Eaton/Cutler Hammer
3. ABB
4. Cooper Power Systems
5. Or equal

2.02 GENERAL

A. One outdoor, three-phase, pad mounted compartmental type liquid immersed medium voltage auxiliary power transformer shall be provided at each traction power facility location as indicated on the Contract Drawings.

B. Liquid immersed medium voltage auxiliary power transformers shall be completely metal enclosed with voltage, primary and secondary winding connections and ratings as specified in Article 2.03 herein.

C. The liquid immersed medium voltage auxiliary power transformers shall be designed for continuous operation at the specified rating, for 24 hours a day, 365 days a year operation.

D. The liquid immersed medium voltage auxiliary power transformers shall be sized for the connected electrical loads plus the spare capacity as specified in the Contract Specifications.

E. Liquid immersed medium voltage auxiliary power transformers and associated anchorage shall be designed to meet the seismic requirements as specified in Section 34 21 01, General Requirements for the Traction Power System.

2.03 RATINGS

A. The liquid immersed medium voltage auxiliary power transformers ratings shall be in accordance with ANSI, NEMA and other applicable standards and shall be as follows:

1. kVA Rating: As indicated on the Contract Drawings.

2. Liquid immersed medium voltage auxiliary power transformers shall have continuous self-cooled kVA ratings, as indicated, based upon average winding temperature rise (by resistance) not exceeding 65 degrees Celsius, and 80 degrees Celsius winding hottest spot temperature over a maximum ambient temperature of 40 degrees Celsius.

3. Primary windings shall be delta-connected with voltage rating 34,500 V. Insulation class (BIL) shall be not less than 150 kV.

4. Impedance: Liquid immersed medium voltage auxiliary power transformers shall be rated as indicated herein and have an impedance of less than or equal to 5.75 percent. Verify adequacy after short circuit and voltage drop calculations.

5. Primary windings shall be provided with six standard, equally-spaced, full capacity taps, three 2-2 1/2 percent above and three 2-2 1/2 percent below the nominal rated line to line nominal voltage.

6. Secondary windings shall be wye-connected, 4-wire, rated 480/277 V, 30 kV BIL. Winding neutral shall be solidly grounded and shall have a minimum insulation level of 10 kV.

7. Angular displacement between primary and secondary winding phase voltages shall be standard.

8. Sound level shall not exceed the maximum permissible values for applicable ratings under standard conditions of measurement. Refer to Section 34 21 01, General Requirements for the Traction Power Systems, for additional requirements.

2.04 ENCLOSURE

A. General

1. The pad-mounted compartmental type liquid immersed medium voltage auxiliary power transformer shall consist of a tank with high-voltage and low-voltage cable terminating compartments separated by a barrier of metal or other rigid material. The high-voltage and low-voltage compartment shall be partitioned such that high and low voltage sides are isolated from each other. When viewed from the front, the low-voltage compartment shall be on the right.

2. Each compartment shall have a door that is constructed so as to provide access to the high-voltage compartment only after the door to the low-voltage compartment has been opened. Where the low-voltage compartment door is of a flat panel design, the compartment door shall have three-point latching with a handle provided for a locking device. Hinge pins and associated barrels shall be constructed of corrosion-resistant material, passivated AISI Type 304.

3. The liquid immersed medium voltage auxiliary power transformer tank and compartments shall be so constructed as to limit disassembly, breakage, and prying open of any doors, panels and sills with the door in the closed and locked position. The bottom edges of the compartment shall be so constructed as to provide for the use of hold-down devices that are accessible only from the inside of the compartments. Construction of the unit shall be such that it can be lifted, skidded, slid, or any combination of these, into place on the mounting surface without disturbing the high-voltage or low-voltage cables.

4. Jacking facilities shall be provided on the tank. The vertical clearance for a jack shall be 1.5 inches minimum and 6.5 inches maximum. The transformer shall be provided with lifting provisions that are permanently attached and arranged on the tank in such a manner as to provide a distributed balanced lift in a vertical direction for the completely assembled transformer. The liquid immersed medium voltage auxiliary power transformer shall be designed to provide a safety factor of 5 in accordance with the requirements of IEEE C57.12.26.

5. Ground enclosure door(s) to the enclosure by means of a visible, flexible copper grounding strap.

6. Terminal identification shall be provided.

7. “Danger High Voltage” warning signs shall be placed on high voltage access panels and doors.

8. Diagram instruction plate shall be placed on each door and removable panel.

9. Refer to the Contract Drawings and Section 26 05 53, Identification Requirements, for additional identification requirements.

B. Core

1. Core shall be constructed of non-aging, cold rolled, high permeability silicon strip, firmly clamped by fiberglass bands and structural steel members and insulated bolts.

2. Core design shall minimize and isolate sound transmission caused by excitation currents.

3. Core and coil assembly shall be rigidly braced to withstand, without degradation, the mechanical forces under short-circuit conditions and resist normal vibration and shock forces during shipment and installation.

4. Core clamps and structural steel members shall be grounded to the enclosure frame by a bolted copper strap.

C. High and Low Voltage Terminals

1. The design, electrical characteristic, clearances location and arrangement of the completely assembled high and low-voltage terminals shall conform to IEEE C57.12.26.

D. Nameplate

Identical nameplate shall be located in two places: On the door and within the low-voltage compartment. The nameplate information shall conform to IEEE C57.12.00. The high-voltage BIL shall be included on the nameplate.

E. Tank

1. The liquid immersed medium voltage auxiliary power transformer tank shall be of sufficient strength to withstand an internal static pressure of 7 psig without permanent distortion and 15 psig without rupturing or displacing components of the auxiliary power transformer or affecting cabinet security. The manufacturer shall certify that design tests have been made on representative samples and submit documentation thereof. A one inch upper plug or cap for filling and pressure testing shall be provided. A one inch NPT drain valve with built-in sampling device shall be provided. Both the filling plug or cap and the drain valve shall be located within the low-voltage termination compartment.

2. Gasketed joints shall have machined surfaces on both sides, and shall be provided with gasket retainers and metal-to-metal stops; this assures even and effective pressure, and avoids over-stressing the gasket. Gaskets shall maintain oil-tight joints under normal service conditions.

3. The tank ground provision shall consist of two stainless steel pads, each with a 1/2-13 UNC tapped hole, 7/16 inch deep. These ground pads shall be welded on or near the transformer base: one in the high-voltage compartment and one in the low-voltage compartment.

4. Liquid immersed medium voltage auxiliary power transformer tanks shall be of sealed-tank construction. The transformer shall remain effectively sealed for a top oil temperature range of minus 5 degrees Celsius to plus 105 degrees Celsius continuous and under operating conditions described in IEEE C57.12.90 and IEEE C57.12.92.

5. The liquid immersed medium voltage auxiliary power transformer shall be provided with dial type, winding hot-spot temperature indicator. Setting shall be recommended by the liquid immersed medium voltage auxiliary power transformer manufacturer. The liquid immersed medium voltage auxiliary power transformers shall also be provided with pressure relief valve and oil level gauge as required.

F. Auxiliary Power Transformer Oil

1. The liquid immersed medium voltage auxiliary power transformer shall be filled with natural ester-based insulating fluids (such as Envirotemp FR3 fluid) which are classified as less-flammable transformer fluids, defined by NEC, as well as non-toxic and biodegradable.

2.05 TERMINATIONS

A. Power and control cables shall enter and leave the liquid immersed medium voltage auxiliary power transformers at the bottom. Provisions shall be made to accommodate the cables.

B. Medium voltage AC power cable terminations shall be deadfront (elbow) connectors that satisfy the requirements of IEEE 386, Section 34 21 19, Separable Insulated Connector, and Section 34 22 23, Traction Power Cables.

C. Low voltage terminations shall be as specified in the Section 26 05 24, Low Voltage Wires and Cables.

2.06 EQUIPMENT PROTECTION AND CONTROL DEVICES

A. Winding temperature, Device No. 26 shall be provided and mounted for viewing from outside of the liquid immersed medium voltage auxiliary power transformer enclosure through a viewing window. The temperature gauge shall be provided with two stage contacts. First stage contact shall be for local and remote annunciations and second stage contact for tripping the associated circuit breaker as indicated on the Contract Drawings.

1. The pick-up point of the first stage shall be adjustable and factory set so that upon a designated temperature increase the device initiates an alarm.

2. Further temperature increase, the device shall initiate the tripping of the associated circuit breaker.

2.07 APPURTENANCES AND AUXILIARY DEVICES

A. Liquid immersed medium voltage auxiliary power transformer appurtenances and auxiliary devices, such as wiring devices, low voltage wires and cables shall be as specified in Section 34 21 50, Common Materials and Methods for Traction Power System.

2.08 MAINTENANCE ACCESSORIES

A. Provide at least the following accessories for each liquid immersed medium voltage auxiliary power transformer:

1. Equipment needed for the normal operation and preventive maintenance of the liquid immersed medium voltage auxiliary power transformers.

2. Special tools required for obtaining access to and replacement of equipment or device in the liquid immersed medium voltage auxiliary power transformers. Tools for tap changer and fuse removal (if applicable) shall be provided.

3. Provide a ground set. Each ground set shall have label identifying the traction power facility and liquid immersed medium voltage auxiliary power transformer designations as indicated on the Contract Drawings. Ground set labels shall be a round disc 2 inches to 3 inches in diameter affixed to the ground cable with non-conductive straps. Ground set cable size shall be at least # 250 kcmil copper.

2.09 FACTORY INSTALLATION

A. Fabricate each liquid immersed medium voltage auxiliary power transformer with all equipment, devices, accessories and appurtenances in place for fully functioning and operable liquid immersed medium voltage auxiliary power transformer.

2.10 FACTORY ACCEPTANCE TESTING

A. Refer to Section 01 45 24, Testing Program Requirements, for additional requirements.

B. Prior to scheduling factory acceptance test witnessing by the Engineer, ensure:

1. Liquid immersed medium voltage auxiliary power transformers and associated equipment, cabling, and appurtenances shall be completely installed per the approved equipment vendor design.

2. All identifiers shall be installed.

3. Liquid immersed medium voltage auxiliary power transformers and associated equipment shall be cleaned.

C. Perform the following standard factory tests on all equipment provided under the Contract. All tests shall be in accordance with IEEE C57.12.00, C57.12.90 and C57.12.98:

1. Resistance measurements of all windings on the rated voltage connection of each unit and at the tap extremes of one unit only of a given rating.

2. Ratio tests on the rated voltage connection and on all tap connections.

3. Polarity and phase-relation tests on the rated voltage connections.

4. No-load loss at rated voltage on the rated voltage connection.

5. Exciting current at rated voltage on the rated voltage connection.

6. Impedance and load loss at rated current on the rated voltage connection of each unit and on the tap extremes of one unit only of a given rating.

7. Applied potential test.

8. Induced potential tests.

D. Perform the following special factory tests on the equipment provided under the Contract. All tests shall be in accordance with IEEE C57.12.00, C57.12.90 and C57.12.98.

1. Temperature test shall be made for each kVA rating specified. Where more than one unit of a given kVA rating applies, only one unit needs to be tested. Tests shall not be required when there is a certified record of a temperature test available on a duplicate unit.

2. BIL impulse test on all windings.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions for compliance with requirements for the liquid immersed medium voltage auxiliary power transformers.

B. Note items that may infringe on the necessary clearances for the equipment and other non-compliances. Promptly bring noted issues to the attention of the Engineer correct deficiencies prior to proceeding.

3.02 FOUNDATION COORDINATION

A. Examine foundations, anchor bolts and levelling channel, and exposed grounding embed conditions for compliance with the approved construction design and vendor’s requirements prior to placement of the liquid immersed medium voltage auxiliary power transformers.

B. Note items that may infringe on the necessary clearances and other non-compliances. Promptly bring noted issues to the attention of the Engineer and correct deficiencies prior to proceeding.

3.03 WIRING, TERMINATIONS AND CONDUIT WORK

A. Refer to the following Sections for requirements:

1. Section 20 50 13 Raceways for Facility Services
2. Section 20 50 16 Underground Ductworks and Structures for Facility Services
3. Section 26 05 24 Low Voltage Wires and Cable
4. Section 34 21 19 Separable Insulated Connectors
5. Section 34 21 50 Common Materials and Methods for Traction Power
6. Section 34 22 23 Traction Power Cables

3.04 GROUNDING

A. Refer to Section 34 21 60, Grounding and Bonding for Traction Power Facilities, for the grounding and bonding requirements.

3.05 INSTALLATION

A. All liquid immersed medium voltage auxiliary power transformers, materials, and appurtenances shall be installed in accordance with NECA 410, and as recommended by the manufacturer.

B. Provide leveling channels and anchorage items as required, and field check to ensure proper alignment and location. Provide templates and layout drawings to ensure correct placing of anchorage items. Check embedded items for correctness of location and detail before concrete is placed.

C. Confirm liquid immersed medium voltage auxiliary power transformers and associated materials are in conformance with the approved Shop Drawings prior to placement.

D. Install each transformer on the foundation secure, level with stainless steel shims, plumb and in true alignment with related adjoining work. Secure the transformers to the foundations in accordance with equipment vendor’s recommendations and the approved seismic design.

E. Install supporting members, fastenings, framing, hangers, brackets, straps, bolts, and angles as required to set and rigidly connect the auxiliary power transformers, and to meet approved seismic design.

F. Provide temporary bracing, guys, or other devices as required to accomplish erection and to providing safety and stability until work is in final position and approved.

G. Control erection tolerance requirements so as not to impair the strength, safety, serviceability, or appearance.

H. Exercise care during installation to avoid overloading any part of the structure. Repair or replace any item damaged due to overloading, at no cost to the District.

I. Transformers located in damp or wet locations, shall be placed and equipped to prevent moisture or water from penetrating and accumulating within the enclosure.

J. Ensure the transformers are not in direct contact with the concrete foundation.

K. Apply waterproof, non-hardening sealing compound or grout between the foundation and the base perimeter of the transformer enclosures.

L. Verify transformers and associated materials are correctly installed in accordance with the approved installation manual and drawings.

M. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not available, use those specified in UL 486 A and B.

N. Protect transformers and associated materials during field installation and field testing activities. Repair or replace items damaged at no cost to the District.

O. Complete the installation and cleaning of transformers, associated materials, and conduits before starting wire and cable installation.

P. Thoroughly clean transformers in accordance with the manufacturer's recommendations prior to installation verification and field testing.

Q. Leave the transformer lifting lugs, complete with boxed hardware, in the DC equipment house for future use by the District. Clearly label lugs and hardware.

R. Interconnect indication functions specified in this Section to the C02 panel for local and remote operation and monitoring. Refer to the Contract Drawings and Section 34 21 33, Traction Power Control, Monitoring and Display Panel, for additional requirements.

S. Refer to Section 34 21 70, Traction Power Facilities Installation Requirements, for additional requirements.

3.06 FIELD TOUCH UP

A. Remove paint splatters and other spots.

B. Clean and repaint damaged interior and exterior surface coatings of transformers using touch up paint provided by the transformer manufacturers.

C. Painting shall follow the recommendations of the transformers paint manufacturers.

D. Protect the appearance of a new installation prior to final acceptance.

3.07 INSTALLATION VERIFICATION, FIELD FUNCITONAL AND SYSTEM INTEGRATION TESTING

A. Refer to Section 34 21 80, Traction Power System Field Acceptance Testing, for requirements.

3.08 CLEANING

A. Refer to Section 01 74 14, Cleaning, for additional requirements.

B. On completion of installation, the Contractor shall inspect the transformers. The Contractor shall remove paint splatters and other spots. The Contractor shall vacuum dirt and debris. Compressed air to assist in cleaning shall not be used. The Contractor shall repair exposed surfaces to match original finish.

3.09 DEMONSTRATION AND TRAINING

A. Refer to Section 01 79 00, Demonstration and Training, for requirements.

B. Contractor shall provide equipment demonstration and training for the District's maintenance personnel to adjust, operate, and maintain the transformers and accessories.

3.10 CLOSEOUT PROCEDURES

A. Refer to Section 01 77 00, Closeout Procedures, and Section 01 78 39, Project Record Documents, for requirements.

END OF SECTION 34 21 27

SECTION 34 21 28

AUXILIARY TRANSFORMERS (DRY TYPE)

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Dry-type transformers.

1.02 RELATED SECTIONS

A.	Section 01 33 00	Submittal Procedures
B.	Section 01 33 23	Shop Drawings, Product Data, and Samples
C.	Section 01 45 24	Testing Program Requirements
D.	Section 01 78 23	Operation and Maintenance Data
E.	Section 20 70 26	Common Materials and Methods for Electrical Systems

1.03 MEASUREMENT AND PAYMENT

A. General: Dry-type transformers, as specified herein, will not be measured separately for payment but will be paid for as part of the Contract lump sum price for Electrical Work as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. California Code of Regulations:

1. Title 24, Part 3 California Electrical Code

B. National Fire Protection Agency (NFPA)

1. NFPA 70 National Electric Code

C. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE C57.12.01 Standard General Requirements for Dry-Type Distribution and Power Transformers

2. IEEE C57.12.91 Standard Test Code for Dry-Type Distribution and Power Transformers

D. National Electrical Manufacturers Association (NEMA):

1. NEMA ST 20 Dry-Type Transformers for General Applications

1.05 REGULAORY REQUIREMENTS

A. Refer to Section 34 21 50, Common Materials and Methods for Traction Power, for requirements.

1.06 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Product Data: Submit manufacturer's product data of transformers.

C. Operation and Maintenance Data: Submit maintenance data and operating instructions in accordance with Section 01 78 23, Operation and Maintenance Data. In addition to requirements of Section 01 78 23 include the following:

1. Description of the equipment and its components;

2. Recommended list of spare parts; and

D. Test Procedures: Submit Factory Test Procedures per requirements of Section 01 45 24, Testing Program Requirements, herein.

E. Test Reports: Submit certified field test reports.

1.07 QUALITY ASSURANCE

A. Conform to NEMA ST 20 and California Electrical Code, or National Electrical Code, as applicable.

B. Equipment of the same type, size, rating, functional characteristics, and make shall be interchangeable.

1.08 DELIVERY, STORAGE AND HANDLING

A. Ship each unit securely wrapped, packaged, and labeled for safe handling of shipment and to avoid damage.

B. Store transformers in secure and dry storage facility.

PART 2 – PRODUCTS

2.01 EQUIPMENT, APPURTENANCES, AND ACCESSORIES

A. Dry-Type Transformers: Provide two-winding, energy-efficient with copper winding type, Class H transformer with full capacity taps on the high voltage winding in accordance with NEMA ST 20. Autotransformer type is not acceptable. Transformers smaller than 30 kVA shall have the core and coil completely

resin-encapsulated and shall have minimum 185 degrees Celsius insulation with 115 degrees Celsius rise. Transformers larger than 30 kVA shall have 220 degrees Celsius insulation with 150 degrees Celsius rise.

B. Terminals: Terminals of transformer windings shall be extended from the coil for external connection. Terminal identification acceptable to the Engineer shall be provided.

C. Noise Level: Noise level shall not exceed the following values when measured in accordance with NEMA ST 20:

1-9 kVA:	40 dBA
10-50 kVA:	45 dBA
51-75 kVA:	50 dBA

D. Enclosures: Equipment enclosures shall be of NEMA classification suitable for the environment to which equipment is exposed. Where NEMA 4 watertight enclosures are required, ensure that bolt down covers do not cause accessibility problems. NEMA 4 enclosures shall be used in subway locations and in areas exposed to rain, water, or high humidity environment.

E. Finish: Metallic surfaces shall be thoroughly cleaned, degreased, primed with an approved corrosion-inhibitive primer, and finished with a heavy-duty, industrial-grade polyurethane enamel.

F. Nameplate: Provide nameplates showing transformer number. Nameplates shall conform to the requirements of Section 34 21 50, Common Materials and Methods for Traction Power.

2.02 FACTORY TESTS

A. Perform the following factory tests on each transformer unit in accordance with IEEE C57.12.01 and IEEE C57.12.91:

1. Resistance measurements of all windings on the rated voltage connections and on all tap connections of each transformer;

2. Ratio tests on the rated voltage connections and on all tap connections;

3. Phase-relation and polarity tests on the rated voltage connections;

4. No-load losses and excitation current at rated voltage on the rated voltage connections;

5. Impedance and load losses at rated current and rated frequency on the rated voltage connections of each transformer;

6. Applied and induced potential tests;

7. Regulation and efficiency at rated load and voltage;

8. Insulation resistance tests (high voltage to ground, low voltage to ground, high voltage to low voltage); and

9. Perform temperature tests in accordance with IEEE C57.12.91.

2.03 INSTALLATION

A. Install dry-type transformers as indicated, in accordance with NEMA criteria, and as recommended by the manufacturer. Transformers shall be properly anchored, and the installation shall conform with applicable code requirements for seismic restraints. Transformers shall be maintained dust-free during the construction period and until accepted by the District.

PART 3 – EXECUTION

3.01 FIELD TESTS

A. Verify that circuits are connected in accordance with the applicable wiring diagrams.

B. Verify that circuits are continuous and free from short circuits.

C. Verify that the insulation resistance to ground of non-ground conductors is megger tested to not less than 10MΩ.

END OF SECTION 34 21 28

SECTION 34 21 30

NEGATIVE GROUNDING DEVICE

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. General requirements

B. Thyristor assembly

C. Analog signal sensor

D. Controller

E. Manual by-pass switch

F. Bus, bus connections and shunts

G. NGD enclosure

H. Test and maintenance accessories

I. Factory testing

1.02 RELATED SECTIONS

A. Refer to the following Sections for requirements:

1. Section 01 33 00 Submittal Procedures
2. Section 01 33 23 Shop Drawings, Product Data and Samples
3. Section 01 42 19 Reference Standards
4. Section 01 43 00 Quality Assurance
5. Section 01 45 00 Quality Control
6. Section 01 45 24 Testing Program Requirements
7. Section 01 78 39 Contract Record Documents
8. Section 20 72 25 Factory and Field Testing
9. Section 27 13 01 Communication Cables and Related Equipment
10. Section 34 21 21 Transformer-Rectifier Units – Oil Filled Transformer, Uncontrollable Rectifier

11. Section 34 21 22 Transformer-Rectifier Units – Dry-Type Transformer, Uncontrollable Rectifier

12. Section 34 21 25 DC Switchgear

13. Section 34 21 33 Traction Power control, Monitoring and Display Panel

14. Section 34 21 35 Emergency and Transfer Trip System

15. Section 34 21 40 DC Control Power System

16. Section 34 21 50 Common Materials and Methods for Traction Power

17. Section 34 21 75 Traction Power Facility System Factory Functional Testing

18. Section 34 21 80 Traction Power System Field Acceptance and Testing Requirements

1.03 MEASUREMENT AND PAYMENT

A. Measurement: Negative grounding devices will be measured for payment per individual unit that is fabricated, factory tested, delivered to Jobsite, installed and field functioning tested in accordance with the Contract Documents.

B. Payment: Negative grounding devices will be paid for at the Contract unit price per each individual switchgear cubicle as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCE STANDARDS

A. American Iron and Steel Institute (AISI)

B. Telecommunications Industry Association (TIA):

1. TIA/EIA-232-F Interface Between Data Terminal Equipment and Data Circuit – Terminating Equipment Employing Serial Binary Data Interchange

2. TIA 455 General Requirements for Standard Test Procedures Optical Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and other Fiber Optic Components

3. TIA 455-13 Visual and Mechanical inspection of Fiber Optic Components, Devices, and Assemblies

4. TIA-568.3-D Optical Fiber Cabling and Components Standard

5. TIA-526-14-C Optical Power Loss Measurement of Installed Multimode Fiber Optic Cable Plant

C. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE C37.30 IEEE Standard Requirements for AC High-Voltage Air Switches Rated Above 1000V

2. IEEE C37.90 IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus

3. IEEE C37.90.1 IEEE Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus

D. National Electrical Manufacturers Association (NEMA):

1. NEMA 250 Enclosures for Electrical Equipment (1000V Maximum)

2. NEMA KS1 Heavy Duty Enclosed and Dead-Front Switches (600 Volts Maximum)

E. National Fire Protection Association (NFPA):

1. NFPA 70 National Electric Code

1.05 SUBMITTALS

A. Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Submit the following to demonstrate compliance with applicable standards:

1. Where equipment or materials are specified to conform to the standards of organizations such as ANSI, IEEE, NEMA, and UL, submit evidence of such conformance. The label of the specified agency will be acceptable evidence.

2. As an alternative to the label or listing, submit a written certificate from an approved nationally recognized testing organization, adequately equipped and competent to perform such activities, stating that the items have been tested and that the units conform to the specified standard.

C. Submit the following:

1. Negative grounding device (NGD) product data; providing name of manufacturer; model, brand, and catalog numbers; and one copy each of the applicable standards for each major component. Submittal shall be made in one package with a listing of the components arranged and identified in numerical sequence by article numbers within this Specification section.

2. Design drawings including:
    a. Block diagrams showing functional interfaces between the NGD and the substation rectifier, DC switchgear, SCADA, and communications equipment.
    b. Elementary control diagrams depicting logical functions or equipment including interfaces with SCADA and communications equipment.
3. Design calculations that verify suitable ratings for:
    a. NGD circuit components, cables, and fuses.
    b. Forces generated with 60 KA peak system short circuit current between the 1200V DC system positive and the negative DC cables entering the NGD compartment.
4. Design calculations showing that NGD shunt mounting and buswork can withstand forces generated by peak system short circuits with no mechanical distortion or degradation of connections.
5. Supplier's recommended default NGD settings.
6. Communications interface protocols that demonstrate compatibility with TPSS/GBS Ethernet network, and with Operations Control Center (OCC) SCADA network.
7. Equipment installation drawings showing equipment layout in NGD enclosure. Show spatial configuration, mounting details, and provision for maintenance access.
8. Enclosure finish coating procedures including:
    a. Surface preparation and coating application, including coating thickness.
    b. Manufacturer's data sheets for materials proposed for use.
9. Enclosure finish sample.
10. Factory design and production test procedures and data sheets.
11. Factory design and production test reports.
12. Supplier's recommended field test procedures and data sheets.
13. Operations and maintenance manuals.
14. Maintenance data including recommended maintenance materials and spare parts list.

D. Submittals shall be made in electronic format compatible with latest version of AutoCAD, and hard copy format.

PART 2 – PRODUCTS

2.01 GENERAL REQUIREMENTS

A. The NGD thyristor assembly shall be used for connection between the rectifier 1200V DC negative bus and the substation ground mat and shall remain in a non-conducting state during normal system operation, keeping the DC negative return system and ground electrically isolated. When vehicle operations or short circuit current cause voltage potential between the DC negative system and ground to exceed a pre-determined time-voltage threshold profile, the appropriate forward or reverse thyristor shall be triggered. Once triggered, the thyristors shall stay in conduction until the resulting current flow remains below a pre-determined time-voltage threshold, indicating absence of unsafe voltage potential between the 1200V DC negative system and ground.

B. The NGD shall use microprocessor-based logic and shall consist of the following functional elements housed within an enclosure:

1. SCR (thyristor) assembly
2. Firing circuit
3. Analog signal sensing equipment
4. Microprocessor controller
5. LED and relay drivers
6. Output relays
7. Front panel including LCD display and operator controls
8. Manual by-pass switch
9. Substation communications interface

C. The NGD manual bypass switch shall be used to connect the DC negative system to TPSS ground when the NGD is removed from service for maintenance.

D. The NGD equipment and accessories shall be mounted in a dedicated outdoor-type enclosure. Equipment including thyristor, control panel, relay power supply, bus work, and connecting cables shall be factory-assembled and tested and shall be contained within the NGD enclosure.

E. Provide voltage isolation of controller electronic equipment, relays, and other control equipment from the DC negative return circuits.

F. Environmental requirements:

1. Temperature: Equipment shall function properly in the temperature range of minus 20 degrees Celsius to 55 degrees Celsius, per IEEE 37.90-5.1.1.

2. Humidity: Equipment shall function properly with an average relative humidity of up to 55 percent and ambient temperature of up to 40 degrees Celsius outside the enclosure, with excursions of up to 95 percent for a maximum of up to 96 hours, without causing internal condensation in accordance with IEEE 37.90-5.1.2.

3. Dust: Outdoor type NGD enclosures shall at a minimum meet the requirements of a NEMA 3R type installation. Solid state and electro-mechanical equipment, relays, microprocessors, and ancillary equipment shall function continuously in this class of environment.

4. System Electrical Transients: The design shall provide protection against damage to the NGD, false triggering, and erratic operation due to transients appearing on the DC system negative with respect to ground. Include transient filtering devices, allowing equipment to meet the requirements of IEEE C37.90.1.

2.02 THYRISTOR ASSEMBLY

A. The thyristor assembly shall consist of semiconductor-controlled-rectifier (SCR) devices configured to transmit current in both directions. Each array of directional SCRs may consist of groups of more than one in parallel, but the design shall minimize the number of parallel devices while still meeting required ratings. Series configurations shall not be used.

B. Definitions:

1. SCR positive current direction – ground to substation DC negative bus

2. SCR negative current direction – substation DC negative bus to ground

C. Current Balance:

1. For both forward and reverse functional SCR groups, all SCRs in the group shall be matched such that the current conducted by each individual SCR is within plus or minus 10 percent of the current conducted by each of the other SCRs within that group.

2. Submit test reports and certification by the manufacturer of the SCR assemblies that each assembly meets this current balance criterion over the SCR current operating range specified.

3. The thyristor controls shall ensure current balance through parallel SCR groups using close coupling reactors or other means so that firing in both forward and reverse direction causes simultaneous activation and firing of all thyristors in the group to avoid overloading of individual components.

D. SCRs shall be appropriately rated in order for the NGD to withstand the operating conditions including voltage levels and frequencies as listed below, and achieve the specified reliability figures. SCR assembly shall meet the following minimum ratings:

1. Minimum voltage rating: 3,000 V DC

2. Current ratings for SCR assemblies:

   a. 60 kA for 8 cycles (0.13s)

   b. 20 kA for 15 cycles (0.25s)

   c. 3 kA continuous operation

E. Only standard devices and standard mounting hardware for SCR devices are acceptable.

F. Cooling: SCRs shall be mounted on heatsinks and cooled using natural convection. Heatsinks and thyristor mounting arrangement shall be provided to limit maximum junction temperature to no greater than 25 degrees C less than the rated maximum junction temperatures when operating under any of the current levels specified in Paragraph D above. The NGD unit shall not require the use of fans for cooling.

2.03 ANALOG SIGNAL SENSOR

A. Required voltage and current indications shall be obtained using an analog signal sensor with a millivolt shunt. The analog signal sensor shall communicate with the NGD controller by a fiber optic cable to electrically isolate the analog signal sensor from the controller. Provide a signal sensor with a minimum 13-bit analog-to-digital converter and local microcontroller to transmit digital data to the NGD controller. The controller shall monitor the signal sensor integrity over the fiber link.

B. Provide analog signal sensor with the following minimum characteristics:

1. Isolation:

   a. Continuous: 1,200 VDC

   b. Peak: 4 kV DC

2. Accuracy: plus or minus two percent full scale

3. Range: 0 to 5kA

C. Hall effect devices to sense current values shall not be used.

2.04 CONTROLLER

A. A solid state NGD controller shall manage required NGD functions including microprocessor-based logic, thyristor firing circuit, analog signal sensor, LED driver, digital I/O, output relays, operator interface, and communication controller.

B. Control circuitry shall include the following characteristics:

1. Mount circuitry on plug-in printed circuit boards

2. Electrically isolate control circuitries from SCRs.

3. Provide test points on the printed circuit boards for ease of use during testing.

4. Indicate typical scope patterns in the schematic drawings at various troubleshooting points.

C. Control logic shall enable SCR firing circuit upon:

1. Detection of DC negative return system or ground overvoltage

2. Command from the microprocessor originating from key pad

D. Display shall be TFT/LCD active matrix, with the following minimum characteristics:

1. Active area: 30 square inches

2. Diagonal size: 8.0 inches

3. Resolution: VGA, 640 by 480 pixels

4. Response time: 80 ms

5. Brightness: 380 nits

6. Contrast Ratio: 250

E. In the main operating mode, the display shall show, at a minimum, the measured values for voltage, current, accumulated amp-hours, counters for SCRs firing in each direction, incoming 120V AC voltage, and station battery 125V DC voltage. On the display submenus, user shall be able to access all system parameter settings, event log, system clock time/date, security level, and test parameters.

F. Touch Pad: Touch pad shall allow operator to easily navigate display menus, access and change numeric system parameters, access stored voltage and current data, and adjust display contrast. Touch pad shall allow:

1. System and alarm reset

2. Manual fire – positive and negative SCR

3. Manual bypass switch release

4. Help – Allow access to context sensitive help

G. LEDs: Controller shall be provided with front panel LEDs to indicate the following:

1. Bypass switch unlocked

2. SCR firing

3. 125 VDC control voltage OK

4. 120 VAC control voltage OK

5. System OK

H. Security Levels: The NGD shall provide the following password-protected security levels, as a minimum:

1. Observer: No password required, allows user to view NGD parameter settings and stored data, but does not allow modify system parameter settings.

2. Operator: In addition to observer level permissions, allows user to:

a. Modify time and date

b. Download alarm log and stored data traces

c. Modify parameters

I. Menus: User interface shall provide intuitive pull-down menus that easily facilitate navigating the screens and selecting system parameters.

J. Microprocessor Logic:

1. Logic and control functions shall be microprocessor based with digital outputs. Provide programming capability in electrically programmable read only memory (EPROM) or other similar solid-state non-volatile memory devices allowing reprogramming of the memory. System parameters shall be able to be entered on the keypad and read/verified on the alphanumeric display. Software programming required shall be provided for a fully functional unit.

2. The control circuits shall provide for manual and automatic operation of the NGD. Remote control operation is not required. Automatic operation will be the normal mode of control. In automatic operation the NGD voltage sensing circuits shall control triggering of the thyristors, indicators, and relay circuits.

K. Memory: Provide the following:

1. Program memory: Use non-volatile flash memory or equivalent to store system program, and to allow upgrading of the software remotely and without physical removal of the chip.

2. Nonvolatile memory: Provide nonvolatile memory (NVRAM) to store system parameters, alarm log, and voltage and current snapshots captured during SCR triggering. Write operation of NVRAM shall be disabled if the voltage drops below a minimum level. Critical parameters and snapshot data shall be retained in the event of a complete power loss.

L. Firing Circuit: Firing circuit shall provide firing pulses to the hardware to instantly trigger the appropriate positive or negative SCR assembly. Firing pulses shall be synchronized as required to ensure simultaneous firing and conduction of current in each SCR of the forward and reverse SCR groups.

M. Communications Ports:

1. A dedicated fiber optic communications port shall provide a high-speed serial interface between the controller and the analog signal sensor. The controller shall monitor the integrity of the amplifier and the link.

2. Primary Ethernet Port: A minimum 10/100 Mbps primary physical Ethernet port to communicate with the control and annunciator panel (C02) PLC, as specified in Section 34 21 33, Traction Power Control, Monitoring and Display Panel, and Related Equipment. The interface to the PLC shall be over DNP3 or Modbus protocols. The port shall be equipped with 100BaseFX send/receive port with ST connectors for multimode fiber.

3. Secondary Ethernet Port: A minimum 10/100 Mbps secondary physical Ethernet port to communicate with remote host computers as an IP address over the BARTNet Ethernet system using the TCP/IP protocol. The secondary Ethernet port shall be independent of and non-routable with the primary Ethernet port. The port shall be equipped with a 100BaseFX send/receive port with ST connectors for multimode fiber.

   The secondary Ethernet port shall be locally configurable to permit uploading software upgrades and modifying NGD parameters and downloading stored event logs and data traces. The secondary Ethernet port shall allow viewing and download of NGD settings parameters and system diagnostic data, including:

   a. Analog data: instantaneous DC negative and ground bus voltages, and NGD shunt current.

   b. Alarm log

   c. Softscope data traces

   d. NGD parameter settings

4. Serial port meeting EIA/TIA 232-F.

N. NGD Ethernet Output Functions

The NGD shall recognize and communicate the following outputs through the primary Ethernet port connecting to the C02 panel:

1. High current in positive and negative SCRs

2. Timed current in positive and negative SCRs

3. High current trip control

4. System trouble – indication of any of the following system trouble conditions:

   a. 125VDC station battery undervoltage

   b. 120VAC undervoltage

   c. NGD complete loss of control power – 125VDC primary or 120VAC backup

d. Self-test logic failure

e. Thyristor failure due to excessive on-state voltage or apparent failure to fire following a gate signal

5. Manual bypass switch status (open/closed)

6. Analog data: instantaneous DC negative and ground bus voltages, and NGD shunt current

O. Digital Inputs: Provide at least six (6) digital inputs, each having positive and negative logic capability, suitable for interface via relay contact closures rated 5A, 125 V DC.

P. Output Relays: Provide at least six (6) output relays to interface the NGD controller with the traction substation 125 VDC control circuits, each having one Form C contact, rated 125 V DC, 5A, 24W/60VA minimum switching capacity. Output functions shall be programmable and shall automatically reset when the alarm condition ceases.

Q. Power supplies: Provide following system energy sources:

1. The NGD shall be powered by dual energy sources to power controls, SCR firing circuits, and bypass switch enable solenoid:

   a. Primary power: 125 V DC from the station battery power. This shall be connected to the system input power terminals through an isolating DC/DC converter in the NGD enclosure.

   b. Secondary power: 120V AC shall be connected to the system input power terminals through an isolation transformer and a full wave rectifier in the NGD enclosure.

   c. NGD shall operate satisfactorily at plus or minus 10 percent of specified AC and DC input sources.

   d. Provide appropriate fusing for the dual energy sources.

2. A backup power supply shall power the system clock and critical microprocessor logic in the event of concurrent 120VAC and 125 VDC power failure. The backup power supply shall enable function of clock and retention of system data and parameters for 30 Days, minimum.

3. Provide the microprocessor logic power supply circuit with thermal, current limit, and overvoltage protection.

4. Operation of the NGD shall not cause either side of any power source to be grounded.

R. System Diagnostics:

1. Watchdog: A watchdog circuit shall supervise operation of the controller, such that if the controller fails to toggle watchdog input for more than one second, the watchdog circuit shall store an alarm indication in the alarm log and restart the system. It shall also store the last system state to assist in troubleshooting. Alarm log shall be retrievable at the operator interface or through the RS-232 or Ethernet ports.

2. Provide as a minimum the following series of self-test functions when control power is connected to the NGD:

   a. Test of non-volatile and volatile memory

   b. CPU test

   c. Power supply voltages normal

   d. System monitoring active

   e. Ethernet connections active

3. If any of the start-up tests have failed or if the watchdog timer is not satisfied, the NGD System Trouble alarm shall indicate.

4. Provide a means of resetting the microprocessor and performing the self-test functions to be used during maintenance operations.

5. NGD system trouble shall be indicated locally by an LED and an alarm contact activated for remote reporting of the system trouble. Provide settable option for firing or inhibit firing.

6. The program shall provide a function, that in the event of start-up test failure, system trouble, or SCR failure this function can be set to either:

   a. Fire the SCRs to ground the DC negative bus, or

   b. Inhibit SCR firing.

7. Provide capability to access internal system diagnostics both through the operator touch pad, through a PC via the RS-232 connection, and through the Ethernet connection.

S. Data Recording and Retrieval:

1. Alarm Memory: System shall store a minimum of the 200 most recent alarms with date and time stamp in non-volatile memory. Retain records of following alarms:

   a. Latching alarms related to hardware failure and requiring manual reset, as follows:

      1) Firing fuse failed

      2) SCR failed to close

3) SCR shorted
4) Self-test malfunction
5) Analog signal sensor failure

b. Non-latching alarms in pairs, one for the alarm and another for its clearance, as follows:

1) Current positive (negative bus grounded)/SCR off
2) Current negative (negative bus grounded)/SCR off
3) Instantaneous positive current high/current normal
4) Instantaneous negative current high/current normal
5) Timed positive current high/current normal
6) Timed negative current high/current normal
7) 125 VDC voltage low/voltage normal
8) 120 VAC voltage low/ voltage normal
9) Manual bypass switch closed / switch open

2. Voltage and Current Records

a. Provide built-in software-based oscilloscope (softscope) to allow taking of voltage and current snapshots, before and after a triggering event. Softscope shall have the capability of setting eight simultaneously active triggering events at a minimum. The events shall be selected from a menu including, at a minimum, positive and negative overcurrent, positive and negative overvoltage, and other abnormal system conditions.

b. Data shall be retained in non-volatile memory, retrievable following complete failure of NGD primary and backup power.

c. Data capture upon selectable triggering events shall be provided. Minimum fast and slow sampling rates shall be provided as follows:

1) Fast: 65 microsecond/sample, from 220 milliseconds before the event until 40 milliseconds after the event.
2) Slow: 65 millisecond/sample, from 220 seconds before the event until 40 milliseconds after the event.
3) System shall provide full data retention for a minimum of eight events, with fast and slow sampling rates selected concurrently.

T. Programmable Parameters: Provide the following programmable general and system parameters with abbreviations noted:

1. General:

a. Voltage thyristor firing level adjustable from 20V to 150VDC in steps less than or equal to 5V. At set trip level, the firing circuit shall fire the SCR.

b. Voltage delay: the delay time between reaching the voltage firing level and firing of the SCR, adjustable from 1 to 255 milliseconds to avoid frequent firing due to short surges.

c. Instantaneous high current, thyristor current level at which an output relay will issue a high current positive or negative indication, adjustable from 500 to 50,000 A in steps less than or equal to 100 A.

d. Timed current: thyristor current level at which an output relay will issue a timed current positive or negative indication, adjustable from 0 to 1,000 A in steps less than or equal to 5 A.

e. Current time delay: the delay time between reaching the timed current level and providing a timed current positive or negative indication, adjustable from 1 to 300 seconds in steps less than or equal to 10 seconds.

2. System parameters shall be factory set and shall require minimum security level of operator for modification:

a. Switch Operate Current Threshold: used to determine an SCR shorted failure or to allow the manual bypass switch to be opened, adjustable from 1 to 30 A.

b. Switch Operate Voltage Threshold: used to determine if the SCR is ON or to allow the manual bypass switch to be closed, adjustable from 1 to 30 V.

c. Current Adjustment Maximum: the maximum value of offset adjustment in Amperes, adjustable from 1 to 100 A.

d. Battery Threshold: low station battery voltage below which the “125 VDC OK” light goes out and an entry is made in the alarm log, adjustable from 1 to 150 VDC.

e. Incoming Power Threshold: low backup power voltage below which the “120 VAC OK” light goes out and an entry is made in the alarm log, adjustable from 1 to 1500VAC.

f. EPROM Check Sum: used to verify EPROM integrity during the power up test.

U. System Clock: Provide system clock with power backup for 30 days. The system clock shall be capable of being automatically updated by the BARTNet system clock using Network Time Protocol either directly from the BARTNet system or via the substation SCADA Ethernet Switch. The system clock shall allow for setting local time zone and daylight saving time settings. The system shall support synchronization of data records’ timestamps with the corresponding timestamps of other substation devices.

V. Mounting: Controller shall be mounted in an enclosure within the NGD to protect sensitive electronics from moisture and possible splattering of water at the outdoor NGD locations. Mounting enclosure shall be set back a minimum of six (6) inches from the outer NGD doors on a hinged mounting bracket allowing easy access to the electronics at the back of the controller unit.

2.05 MANUAL BYPASS SWITCH

A. Fixed-mounted, no-load, single pole, single throw, bolted pressure type manual bypass switch shall be provided with the NGD assembly, that shall bypass the NGD during maintenance. Switch position indicator shall be visible through a viewing window.

B. Voltage rating: 3,000V DC, minimum.

C. Current rating: Equal to positive SCR assembly rating.

D. Insulation: Insulate live metal parts for 3,000V DC, minimum.

E. Provide required interlock hardware to prevent operating switch under load. Interlock shall be as follows:

1. It shall not be possible to open the bypass switch unless current magnitude through the switch is less than the switch operate current threshold set value.

2. It shall not be possible to close the bypass switch unless voltage across the switch is less than the switch operate voltage threshold set value.

F. Bypass switch and its interlock circuitry shall be failsafe. Switch operation shall require pressing the ‘Switch Operate’ key on the operator touch pad.

G. Provide normally open and normally closed auxiliary contacts for indication of bypass switch status.

2.06 BUS, BUS CONNECTIONS, AND SHUNT

A. A two-inch minimum clearance between bus work and the NGD enclosure or other metal parts shall be maintained.

B. DC bus shall be fabricated of rigid, high quality copper, rated 5,000 amperes and capable of carrying the indicated overloads without exceeding the allowable temperature rise as specified in ANSI, IEEE, and NEMA standards. Bus and bus connections shall be of adequate strength to withstand thermal and mechanical stresses associated with the maximum short-circuit currents equal to the current rating of the forward thyristor assembly.

C. Bus connections shall be silver-plated bolted copper bus connections including bus taps, and shall allow each joint to have conductivity at least equal to that of the bus bar. Provide Belleville washers and hardware for the bolted assemblies. Provide connections of a type that will not deteriorate with cyclic loading or lose pressure.

D. Design bus work so that cable entry into the NGD unit is made as simple as possible, minimizing negative DC system and ground cable routing in the NGD enclosure and allowing easy access for cable terminations and inspection. Provide provisions for four 750 kcmil ground cables and four 750 kcmil cable connections to DC negative system. Use standard NEMA 2-hole standard cable lugs.

E. Shunt: Provide DC shunt integral with bus work to interface with analog signal sensor equipment, with following characteristics:

1. Rating: 5KA

2. Accuracy: plus or minus 0.25 percent of rated value, maximum deviation

3. Temperature coefficient: plus or minus 0.000015 maximum, per change of degree Celsius

4. Support: Shunt support shall be designed to withstand short circuit forces.

2.07 NGD ENCLOSURE

A. NGD enclosures shall be self-supporting units, rated NEMA 3R, with the following characteristics:

1. The enclosure structure shall be of rigid, self-supporting and self-contained electrically welded sheet steel that is sufficiently rigid to support equipment under normal and short-circuit conditions. Structural support shall ensure enclosure orthogonality to enable smooth door operation. Panels shall be fabricated of nor less than No.11 sheet steel framework.

2. Access doors shall be fabricated of not less than No. 14 gauge sheet steel.

3. Provide two-point latching handles on doors.

4. Base shall be provided with mounting channels not less than three inches nor more than five inches high with a three-sixteenths inch minimum web.

B. Unit shall contain louvered expanded metal or mesh-covered openings to provide adequate ventilation and air-cooling for the components. Ventilation louvers shall have splashguards.

C. Provide dimpled or slanted roof allowing drainage of rainwater and condensation to unit rear or sides.

D. Doors and view windows shall have gaskets to ensure that door and window seals are moisture tight.

E. Provide detachable rain hood, as indicated, above the enclosure access doors for use in outdoor locations. Rain hood shall be affixed to top of enclosure in such a way that no holes or openings into the enclosure interior for screws or bolts are required. Rain hood shall extend a minimum of one foot beyond the front face of the enclosure.

F. SCR assembly, power supply, and other sensitive electronic equipment shall be positioned in the enclosure so that equipment is protected from splattering water when NGD front enclosure door is opened.

G. Provide switch-operated 120V AC light fixture providing 600 lumens minimum, placed to directly illuminate the NGD control panel within the enclosure.

H. Provide duplex, 20A, GFCI receptacle within the enclosure.

I. Provide space heater sufficient to maintain interior of NGD unit free of condensation and moisture at all times.

J. Provide convenient access to internal components for normal maintenance and inspection. NGD control panel shall have a 6-inch to 12-inch setback from enclosure door. Provide stainless steel, abrasion-resistant hasp for padlock on enclosure doors.

K. Enclosure Finish:

1. Enclosure finish surface shall be cleaned, primed, treated with a galvannealed coating, and finished with a powder coat.

2. The galvannealing coating process shall be a two-step coating process with the following characteristics:

   a. Lower coating shall be 10 percent iron-zinc allow deposited by the hot-dip process.

   b. Lower coating weight: 60 g/m^2, minimum.

   c. Upper coating shall be 80 percent iron-zinc alloy electroplated deposited by the hot-dip process.

   d. Upper coating weight: 3 g/m^2, minimum.

   e. Corrosion resistant capabilities: Maximum 1/8-inch creep corrosion when vertically scribed and exposed to five percent salt fog per ASTM B117 for 1500 hours.

3. The powder coating process shall be a two-step process with the following characteristics:

   a. Thickness; 5 mils, minimum

   b. Color:

      1) Powder coat: Medium beige, Sherwin Williams (#SW6106) or equal.

      2) Wet paint and aerosol colors: Medium beige, to match powder coat.

   c. Weather, graffiti, and ultra-violet (UV) resistant.

   d. Following assembly of enclosure, areas that have been affected by cutting or welding shall be spot-galvanized with a primer that forms a dry film no less than 90 percent pure zinc. Touch-up paint shall be applied to match the powder coat finish.

4. Coatings, field or factory applied in California, shall comply with the latest regulations of the California Air Resources Board (CARB) and the Bay Area Air Quality Management District regarding regulations governing permissible content of volatile organic compounds.

L. Provide minimum of 20 Days' notice prior to fabrication of house exterior panels for the Engineer's inspection and independent assessment of finish characteristics to determine specification compliance. Finish characteristics shall be confirmed by the Engineer's independent inspection prior to commencement of house construction.

M. Provide enclosure with AISI Grade 316 stainless steel accessories, including door handles, hinge pins, padlock hasp, and rain hood attachment hardware.

N. Nameplates: Enclosure nameplates shall be as follows:

1. Fabricated of three-ply laminated phenolic plates with bevel edges, engraved through the black face to expose the white core. Lettering shall be condensed gothic, applied using a rounded or square cutter. V-shaped grooves will not be acceptable.

2. Nameplates showing enclosure designation shall have lettering not less than two inches high. Provide two nameplates for enclosure front and back, with designations as specified by the District.

3. Nameplates identifying relays, switches, controls, fuses, and other auxiliary devices shall have lettering not less than 1/16 inch high, and shall include ANSI device designations, as appropriate. Nameplates for fuses shall include fuse rating and circuit indication.

2.08 TEST AND MAINTENANCE ACCESSORIES

A. Furnish one (1) complete set of special tools and test equipment for each 5 NGDs delivered. If fewer than 5 NGDs are provided, provide one (1) complete set. Each set shall comprise hardware and software necessary for field testing, diagnostics, maintenance, and repair of the NGD, including the isolation transducer. At a minimum, each set of test apparatus shall comprise the following:

1. Laptop computers shall be the current generation subject to District approval, the applicable model at time of bid, and shall include the following minimum capabilities:

   a. Quad-core processor

   b. 2.5 GHz processor speed

   c. 8 GB DDR4 3200 MHz RAM memory

   d. 1 TB solid state hard drive

   e. One Ethernet port, one serial port or detachable RS-232 adapter, and two USB ports

   f. 14-inch LCD flat panel display

   g. Minimum 8-hour battery charge during warranty period

   h. Latest operating system compatible with MPR software

2. The laptop computer wi-fi shall be capable of being disabled.

3. Software required for NGD testing, set-up, and diagnostics. Required software licenses shall be included. Software shall be provided on laptop and on separate storage media.

4. Cable connecting hardware needed to connect with the NGD using USB connector at the computer end of the connection.

5. Test apparatus to verify NGD discrete input and output operation. Apparatus shall connect to the discrete input and output I/O ports and shall activate the indicating LEDs to verify correct I/O operation.

6. Any other hardware and software, including cables, laptop carrying case, batteries, and computer software to provide complete and functional test equipment.

2.09 FACTORY TESTING

A. General:

1. Testing of the NGD shall be performed in accordance with the requirements of Section 01 45 24, Testing Program Requirements.

2. Tests shall be performed by a company or agency certified by the National Electric Testing Association (NETA).

3. The District reserves the right to waive any tests.

B. Design Tests: The following design tests shall be performed on one NGD unit:

1. High bandwidth current measurement apparatus capable of accurately recording currents expected during the tests shall be used. Test results shall be in printed or graphical format.

2. Thyristor Assembly: Tests shall be performed to verify the following:

   a. Voltage rating: Continuous and transient voltage ratings.

   b. Transient surge current ratings for positive and negative thyristor assemblies.

   c. Continuous current ratings for positive and negative thyristor assemblies

   d. Current balance: To within plus or minus 10 percent of parallel thyristors in positive and negative thyristor assemblies.

   e. Simultaneous conduction: The test shall show that thyristor legs in the positive and negative current directions successfully conduct at the same time when the thyristor assembly is activated.

3. Analog Signal Sensor: Perform tests in accordance with IEEE 37.90 and 37.90.1 to verify the following:

   a. Voltage rating: Continuous and transient ratings.

b. Transient surge current ratings.

c. Continuous current rating.

d. Sensing unit fiber optic outputs shall be verified for all tests.

4. Sensing and Control Logic: Perform tests in accordance with IEEE 37.90 and 37.90.1 to verify the following operating functions:

a. Logic functions over the full range of selectable voltage and current parameter values.

b. Control function response of anticipated system conditions and NGD equipment failures.

c. Power supply functions and input voltage range characteristics.

d. Function of front panel controls.

5. Input/Output Functions: Verify proper operation of digital inputs, relay outputs, and alarms. Confirm alarms and indications are received at local and remote control equipment. Confirm RS-232 and Ethernet system communications functions can communicate correctly with all local and remote interfacing equipment.

6. Manual Bypass Switch: Verify the following:

a. On/off operation

b. Thyristor interlock function: demonstrate blocking of switch operation during high current and voltage conditions as described in Section 2.05E above.

c. Dielectric voltage withstand capability in accordance with NEMA SK 1.

7. Complete NGD Assembly: Verify isolation between:

a. Live metal parts and enclosure.

b. Live metal parts and control wiring

c. Control wiring and enclosure

C. Production Tests: Each production unit shall be tested in accordance with the design tests specified above with the exception of intermediate and surge current rating tests specified in Articles 2.09B.2.b and 2.09B.3.b.

PART 3 – EXECUTION

3.01 FIELD TESTING

A. Coordinate and perform field testing per requirements of Specification Section 34 22 80, Traction Power System Field Acceptance Testing.

END OF SECTION 34 21 30

SECTION 34 21 33

TRACTION POWER CONTROL, MONITORING AND DISPLAY PANEL, AND RELATED EQUIPMENT

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Requirements for a control, monitoring and display panel (C02 panel), and related communications equipment located in each traction power facility (TPF). BART traction power uses five types of TPFs:

1. Traction Power Substation (TPSS)
2. Gap Breaker Substation (GBS)
3. Sectionalizing Station (SS)
4. Switching Substation (SWS)
5. High Voltage Substation (HVS)

B. Requirements for a supervisory control and data acquisition (SCADA) programmable logic controller (PLC) that is mounted within C02 panel and interfaces with the BART Operations Control Center (OCC) and, where applicable, with the adjacent BART Maintenance Yard Tower New Yard Management System (NYMS).

C. Requirements for a TPF SCADA interface panel (C04), which facilitates TPF SCADA equipment interfaces with the BART Central Offices via fiber optic equipment in the train control room at the passenger station or, where applicable, Maintenance Yard Tower adjacent to the TPF.

D. Requirements for a TPF communications cabinet (CCA), which facilitates TPF security equipment interfaces with the BART Central Offices via fiber optic equipment in the train control room at the passenger station or, where applicable, Maintenance Yard Tower adjacent to the TPF.

1.02 MEASUREMENT AND PAYMENT

A. Measurement: Control, monitoring and display panels, and related equipment will be measured for payment for each unit that is tested and furnished in accordance with the Contract Drawings and Contract Specifications.

B. Payment: Control, monitoring and display panels, and related equipment will be paid for at the Contract unit price for each unit as indicated in the Bid Schedule of the Bid Form.

1.03 REFERENCE STANDARDS

A. Comply with the appropriate industry standards for the respective equipment listed below.

B. American National Standard Institute (ANSI):

1. ANSI C2	National Electric Safety Code (NESC)

C. Electronics Industries Alliance/Telecommunications Industry Association (EIA/TIA):

1. EIA 232-F	Interface Between Data Terminal Equipment and Data Circuits – Terminating Equipment Employing Serial Binary Data Interchange
2. EIA/ECA 310-E	Cabinets, Racks, Panels, and Associated Equipment

D. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE 802.3	Carrier Sense Multiple Access with Collision Detection
2. IEEE 1613	Standard Environmental and Testing Requirements for Communications Networking Devices in Electric Power Substations

E. International Electrotechnical Commission (IEC):

1. IEC 60068	Environmental Testing
2. IEC 60529	Degrees of Protection Provided by Enclosures
3. IEC 61000	Electromagnetic Compatibility
4. IEC 60255	Electrical Relays
5. IEC 61131	Programmable Controllers Package

F. National Electrical Contractors Association (NECA):

1. NECA/FOA 301	Installing and Testing of Fiber Optic

G. National Fire Protection Association (NFPA):

1. NFPA 70	National Electric Code
2. FPA 130	Standard for Fixed Guideway Transit and Passenger Rail Systems
3. NFPA 262	Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces

H. Instrument Society of America (ISA):

1.	ISA 101	Human-Machine Interface

I. Telecommunications Industry Association (TIA):

1.	TIA-455-C	General Requirements for Standard Test Procedure for Optical Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components
2.	TIA 455-13	FOTP-13 Visual and Mechanical Inspection for Fiber Optic Components, Devices, and Assemblies
3.	TIA-526-7-A	Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant, Adoption of IEC61280-4-2 Edition 2: Fibre-Optic Communications Subsystem Test Procedure – Part 4-2: Installed Cable Plant – Single-Mode Attenuation and Optical Return Loss Measurement
4.	TIA-526-14-C	Optical Power Loss Measurement of Installed Multimode Fiber Optic Cable Plant; Modification of IEC 61280-4-1 Edition 2, Fiber-Optic Communications Subsystem Test Procedures Part 4-1: Installed Cable Plant-Multimode Attenuation Measurement
5.	TIA-568.0-E	Generic Telecommunications Cabling for Customer Premises
6.	TIA-568.1-E	Commercial Building Telecommunications Infrastructure Standard
7.	TIA-568.2-D	Balanced Twisted-Pair Telecommunications Cabling and Components Standard
8.	TIA-568.3-D	Optical Fiber Cabling and Components Standard
9.	TIA-569-E	Telecommunications Pathways and Spaces
10.	TIA-606-C	Administration Standard for Commercial Telecommunications Infrastructure
11.	TIA-607-D	Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises

J. Underwriters Laboratories (UL):

1.	UL 94V	Flammability Rating

1.04 ABBREVIATIONS

AC:	Alternating Current
ACS:	Access Control System
BLS:	Blue Light Station
BIOM:	Backup IOM
CCA:	Traction Power Communications Cabinet
CCTV:	Closed Circuit Television
CIP:	Common Industrial Protocol
C02:	Traction Power Control, Monitoring and Display Panel
C04:	Traction Power SCADA Interface Panel
CRC:	Cyclic Redundancy Check
DC:	Direct Current
DOTI:	Districtwide Operational Technology Infrastructure
DNP3:	Distributed Network Protocol 3
EBP:	Emergency Backup Panel
ETTP:	Emergency and Transfer Trip Panel
ETTS:	Emergency and Transfer Trip System
FOT:	Fiber Optic Transceiver
FPP:	Fiber Patch Panel
GBS:	Gap Breaker Station
HMI:	Human Machine Interface
HVAC:	Heating, Ventilation and Air Conditioning
ICS:	Integrated Computer System
I/O:	Input/Output
IOM:	I/O Module
IP:	Internet Protocol
IPR:	Integrated Protection Relay
LAN:	Local Area Network

LED:	Light Emitting Diode
MPR:	Multi-Function Protection Relay
NEC:	National Electric Code
NECA:	National Electrical Contractors Association
NEMA:	National Electrical Manufacturers Association
NGD:	Negative Grounding Device
NYMS:	New Yard Management System
OCC:	Operations Control Center
PDF:	Portable Document Format
PLC:	Programmable Logic Controller
PoE:	Power over Ethernet
PoE+:	Power over Ethernet plus
PIOM:	Programable IOM
PQM:	Power Quality Meter
RTAC:	Real Time Automation Controller
SCADA:	Supervisory Control and Data Acquisition
SFP:	Small Form Factor Pluggable Transceiver
SS:	Sectionalizing Station
SWS:	Switching Station
TCH:	Train Control House
TCP:	Transmission Control Protocol
TCR:	Train Control Room
TPSS:	Traction Power Substation
TPF:	Traction Power Facility
TRU:	Transformer-Rectifier Unit
UPS:	Uninterruptible Power Supply
VLAN:	Virtual Local Area Network

1.05 RELATED SECTIONS

Interface and coordinate the work of this Contract Specifications Section with:

A. Section 01 33 00, Submittal Procedures

B. Section 01 33 23, Shop Drawings, Product Data, and Samples

C. Section 01 35 14, Operating System Interface

D. Section 01 42 19, Reference Standards

E. Section 01 43 00, Quality Assurance

F. Section 01 45 00, Quality Control

G. Section 01 45 24, Testing Program Requirements

H. Section 01 78 39, Project Record Documents

I. Section 01 78 44, Spare Parts and Maintenance Materials

J. Section 20 50 13, Raceways for Facility Services

K. Section 20 70 19, Indoor Cabinets, Racks, Frames and Enclosures

L. Section 26 05 24, Low Voltage Wires and Cables

M. Section 27 13 01, Communication Cables and Related Equipment

N. Section 27 30 01, Telephone Systems

O. Section 28 10 01, Access Control

P. Section 28 41 29, Closed Circuit Television Systems

Q. Section 34 21 11, Multi-Function Protection Relay Equipment for DC Feeder Circuit Breakers

R. Section 34 21 25, DC Switchgear

S. Section 34 21 40, DC Control Power System

T. Section 34 21 50, Common Materials and Methods for Traction Power

U. Section 34 21 60, Grounding and Bonding for Traction Power Facilities

V. Section 34 21 70, Traction Power Facilities Installation Requirements

W. Section 34 21 75, Traction Power Facility Functional Factory Testing

X. Section 34 21 80, Traction Power System Field Acceptance Testing

1.06 SYSTEM DESCRIPTION

A. A C02 panel shall be located in one of the houses or rooms of each TPF. Within that house or room, the C02 panel shall be placed near the facility's main entrance door. Each C02 panel shall be a floor mounted cabinet equipped with two doors as shown on the Contract Drawings. The C02 panel shall include following components:

1. Real Time Automation Controller-type Programmable logic controller (RTAC PLC).

2. An HMI operator panel consisting of an industrial computer, flat screen monitor, keyboard, and mouse. The operator panel shall be mounted on one of the front doors of the C02 panel and shall serve as the operator interface.

3. Hardwired mimic panel.

4. Redundant power supplies for RTAC PLC, RTAC PLC IOMs, and C02 panel associated hardware.

5. IOMs associated with RTAC PLC that provide an interface to the mimic panel and ancillary equipment such as batteries and fire alarms.

6. Miscellaneous relays, terminal blocks, and associated wiring.

7. IOMs associated with TPF backup control system to provide a secondary independent fiber optic interface between C02 mimic panel local controls and TPF breakers. TPF backup control system serves as redundant means of breakers' monitoring and control in case of the failure of TPF's control Ethernet switches, RTAC PLC, associated modules and associated communications path components. IOMs shall be installed in the C02 panel and the matching pair shall be installed within AC and DC switchgear lineups.

8. Interior light fixture with door-activated switch providing 600 lumens minimum and an AFCI 120V AC duplex receptacle.

9. Lamp test button. This may be incorporated in the HMI.

B. The C02 panel shall be fully functional with spare capacity to accommodate monitor devices, control devices, display devices, equipment of the TPF, existing equipment and devices, and additional future equipment as indicated. Depending on the type of TPF, C02 panel shall provide for monitoring and control of all facility equipment as indicated.

C. C02 and C04 cabinets shall be implemented as two separate standalone cabinets. Depending on substation space restrictions, the District may consider having the C02 panel in-house to the C04 panel and the C04 equipment integrated into C02 panel enclosure (see detailed requirements for the C04 panel below).

D. The C02 panel, C04 panel, CCA cabinet and related equipment are based on the use of an industrial grade, off-the-shelf RTAC type PLC, network switches and operator display capable of efficient operation in a harsh electrical, high temperature, vibrating, and physically dirty environment. Obtain District approval in writing of equipment and components.

E. Ethernet physical ports shall be implemented as interfaces over fiber-optic media, 100Mb/s multimode or greater. Some interfaces may use copper Ethernet interface, as shown on the Contract Drawings. There shall be two independent C04 panel Ethernet switches (switch stacks) supporting two independent non-bridgeable VLANs. Equipment shall include the following:

1. One network for use by the C02 PLC data acquisition and control network (Control VLAN).

2. A second network for access to each TPF network device such as MPR, IPR, NGD, IOM, PQM, transformer controller, rectifier controller, ETTS logic controller and, if applicable, 125 VDC TPF battery backup system controller maintenance data (Maintenance and Engineering VLAN).

3. Interfaces between the C02 PLC and other devices in the TPSS shall be as indicated and as specified herein. For devices that support only a single (not dual) IP-addressable physical port, when approved by the District, it is acceptable to implement the Maintenance and Engineering VLAN interface utilizing the devices' spare serial (or USB-serial) ports and terminal server equipment connected to the Maintenance VLAN switch. For such cases, to enable galvanic isolation, this interface shall be done over the fiber optic media that may use, where necessary, fiber optic media converter and terminal server equipment between the origin and the destination of the interface.

F. TPF CCTV cameras and access control panel Ethernet interfaces shall be connected to the Security Ethernet switch in the CCA cabinet. TPF VOIP emergency and IP telephone Ethernet interfaces shall be connected to the VOIP Ethernet switch in the CCA cabinet. The CCA security Ethernet switch shall be configured to be a part of the Security VLAN. The CCA VOIP Ethernet switch shall be configured to be a part of the VOIP VLAN. Both Security and VOIP VLANs shall be independent from the Control VLAN and the Maintenance and Engineering VLAN. The CCTV data shall be passed to a BART centralized location for processing camera video and storage via DOTI Network (see Contract Specifications Section 28 41 29, CCTV for the detailed requirements of the TPSS CCTV System). Correspondingly, the TPF access control panel, access control panel intelligent power supply, and intrusion detection panel indications and controls shall interface BART centralized security office via DOTI Network (see Contract Specifications Section 28 10 01, Access Control for the detailed requirements of the TPF Access Control System). The TPF emergency and VOIP telephones shall provide for telephone signaling with the BART phone system (see Contract Specifications Section 27 30 01, Telephone Systems for the detailed requirements of the TPF Telephone System). The CCA Ethernet switches shall provide for PoE+ compliant power for TPF CCTV cameras and VOIP Emergency and IP telephones. See detailed requirements for the CCA cabinet herein.

G. TPF Ethernet switches shall facilitate interfaces to the corresponding equipment in BART headend offices via single-mode fiber optic uplinks between the TPF site and the existing DOTI Network Ethernet switches located inside the train control room closest to the TPF.

1.07 SUBMITTALS

A. Provide submittals in accordance with Contract Specifications Section 01 33 00, Submittal Requirements and Procedures, Contract Specifications Section 01 33 23, Shop Drawings, Product Data, and Samples, and Contract Specifications Section 01 78 44, Spare Parts and Maintenance Materials.

B. Submit manufacturer's data sheets including catalog data and technical specifications for equipment and devices installed in the C02 panel, C04 panel, and CCA cabinet. Descriptive information shall be sufficient to determine compliance with these Contract Specifications.

C. Submit a detailed design and functional description of the C02 panel, C04 panel, and CCA cabinet, related equipment and an overall mimic bus layout for each traction power facility.

D. Submit software backups, licensing, service and support contracts, and documentation on the configuration of the C02 PLC, IOMs, C02/C04 operator panel, C04 and CCA equipment, FPP and copper patch panel equipment, emergency and IP telephone equipment, and Ethernet switches (and, if applicable, terminal server and fiber media converter equipment), including system configuration block diagrams, functional descriptions, network physical and logical topology diagrams, I/O lists, PLC logic, operator panel display hierarchy, physical and software ports assignments, and IP address assignments.

E. The following quality assurance submittals:

1. Quality assurance and quality control submittals shall be in accordance with Contract Specifications Section 01 43 00, Quality Assurance and Section 01 45 00, Quality Control.

2. Certificates: Where equipment or materials are specified to conform to the standards or publications, and requirements of CFR, ANSI, NFPA, EIA, or UL, submit certificates attesting that the items furnished under this Contract Specifications Section conform to the specified requirements.

F. Manufacturer's Instructions: Where installation procedures, or any part thereof, are required to be in accordance with the recommendations of the manufacturer of the equipment being installed, submit printed copies of these recommendations. Submit operating instructions outlining the step-by-step procedures required for system operation including description of each subsystem in its operating mode. Instructions shall include the manufacturer's name, service manual, parts list, and a brief description of equipment, components, and their basic operating features. Submit maintenance instructions listing regular maintenance procedures, possible system failures, a troubleshooting guide for repairs, and simplified diagrams for the system as installed.

G. Design Submittals

1. Submit the following design submittals:

   a. RTAC, C04 panel and CCA cabinet Ethernet network schematic diagrams. The network diagrams shall identify each VLAN and IP-addressable device within TPF. Each IP-addressable port and, where applicable, networked serial port, shall be identified. Each Ethernet switch port shall be identified, including ports reserved for local maintenance access. Upon approval of the network diagrams, the District will assign DOTI Network IP addresses to each TPF device and each VLAN for the Contractor's implementation. The District will supply the network switch basic configuration files for the Contractor's implementation. The Contractor shall use only the District assigned IP addresses and network switch configuration files for enabling the network interfaces within TPFs during both factory and field testing. Use of privately assigned IP addresses, serial ports, and switch configuration files are not allowed.

   b. C02 panel I/O point lists that match the format indicated in the Contract Drawings.

   c. A complete list of equipment interfaces including interface details, a listing and settings for all IP-addressable devices, and, if applicable, serial ports assignments and their settings, for the District's use. The Contractor shall use only the District assigned IP addresses and network switch configuration files for enabling the network interfaces within TPFs. Use of privately assigned IP addresses, serial ports, and switch configuration files are not allowed.

   d. Logic diagrams and software functional diagrams for all programmable devices, software interfaces, and data descriptions. Logic diagrams are project-specific software diagrams showing logic gates and other boolean and analog elements. The diagrams show calculations of four-state devices (e.g. circuit breakers, switches), relays and controllers' communication offline statuses, breaker control schematics, PLC lockout relay activations, virtual points, automated switch-over, inversing of fail-safe normally closed contacts, and TPF analog values conversions.

   e. HMI operator panel display hierarchy, including site-specific copies of each display, including help displays, and a full description and flow diagrams of display operation and operator interaction. Display formats shall conform to those shown in the Contract Drawings.

2. Submit product data for C02 panel, C04 panel, and CCA cabinet hardware and software.

3. Submit the following data for each cabinet:

   a. Power and grounding requirements.

   b. Heat load.

   c. Environmental limits.

   d. Surge protection equipment.

e. Air-conditioning equipment (where applicable).

f. Calculations for each cabinet's power supply.

g. Calculations for each cabinet's air-cooling.

h. Calculations showing that the C04 panel's swing-out rack meets the rack manufacturer structural requirements and can perform the rack's swing-out functions.

i. Calculations showing that the C04 Panel's swing-out rack meets height requirements.

4. Submit C02 panel layout drawings, including mimic bus layout, for all traction power facilities. Submit C04 panel and CCA cabinet layout drawings. These drawings shall be drawn in scale, and show both front views of the C02 panel, C04 panel and CCA cabinet with the doors closed, and device locations and wiring interfaces with the front doors open. Where TPF connections involve side or back of the C02 panel, C04 panel, or CCA cabinet, submit similar drawings showing the side and back views of the equipment showing related equipment locations and wiring interfaces.

H. Factory and Field Test Plans and Reports: Submit factory and field test plans and reports in accordance with this Contract Specifications Section, Contract Specifications Section 34 21 75, Traction Power Substation Factory Functional Testing, and Contract Specifications Section 34 21 80, Traction Power System Field Acceptance Testing.

I. Operation and Maintenance (O&M) Manuals: Submit O&M manuals in accordance with Contract Specifications Section 01 78 23, Operation and Maintenance Data.

J. Training Materials: Submit training materials in accordance with Contract Specifications Section 01 79 00, Demonstration and Training.

K. Spare Parts List: Submit a recommended spare parts list in accordance with Contract Specifications Section 01 78 44, Spare Parts and Maintenance Materials. The spare parts list submittal shall consist of two sections:

1. Recommended spare parts per the Contract Specifications Section 01 78 44, Spare Parts and Maintenance Materials.

2. Spare parts designated by the District as mandatory.

L. Configuration documentation and applications software in accordance with Article 3.03A of this Specifications Section.

M. Record Drawings: Submit Record Drawings in accordance with Contract Specifications Section 01 78 39, Project Record Documents.

1.08 QUALITY ASSURANCE AND SUPPLIER QUALIFICATIONS

A. Refer to Contract Specifications Section 01 43 00, Quality Assurance for quality assurance requirements.

B. The manufacturer of the equipment under this Contract shall have a minimum of five years of successful and proven design and manufacturing experience in control products for utility or traction power type facilities using 600 V AC or higher, providing equipment similar to the one to be furnished under this Contract.

C. Field testing shall be performed by persons having five or more years of relevant testing experience.

1.09 SPARE PARTS

A. Spare parts shall be categorized into two types as follows:

1. Furnish mandatory spare parts as follows and at a minimum one set:

   a. C02 PLC Assembly (PLC with Power Supplies, Backplane and Discrete and Analog IOMs of each type provided by the Contract): one assembly per three TPFs.

   b. Distributed IOM: two IOMs of each type provided by the Contract per three TPFs.

   c. Ethernet Switches: one Ethernet Switch of each type provided by the Contract per three TPFs.

   d. Terminal Server: one Terminal Server of each type provided by the Contract per three TPFs.

   e. C02 HMI Operator Panel consisting of an industrial computer, flat screen monitor, keyboard, and mouse: one set per three TPFs.

   f. Cabinet's Air-Conditioning Equipment: one device (of highest capacity provided by the Contract) per three TPFs.

   g. 125 VDC to 24 VDC Converters and Other Power Supplies: one DC/DC Converter (power supply) of each type provided by the Contract per three TPFs.

   h. C02 Panel Analog Meter: one meter of each type provided by the Contract per one TPF.

   i. Lockout Relay and Rotary Switches: one device of each type provided by the Contract per three TPFs.

   j. Pushbuttons and Indicating Lights: two devices of each type provided by the Contract per three TPFs.

   k. AT6 Patch Panel, FPPs: one device of each type provided by the Contract per three TPFs.

   l. SFPs and Media Converters: one device of each type provided by the Contract per one TPF.

   m. Surge Protection equipment: one device of each type provided by the Contract per three TPFs.

n. Fuses: One box of 20 fuses of each type provided by the Contract per three TPFs.

2. Recommended spare parts by manufacturer shall be furnished in addition to the mandatory spare parts identified above in accordance with the requirements included herein.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Equipment shall be weatherproofed for shipment. Connection openings shall be closed to prevent entrance of foreign material during shipment and storage.

B. Equipment shall be handled and stored in conformance with manufacturer's instructions. One copy of these instructions shall be included with the equipment at time of shipment.

PART 2 – PRODUCTS

2.01 GENERAL

A. Environmental Requirements: System equipment shall be designed to conform to the environmental conditions defined in Contract Specifications Section 34 21 01, Traction Power General Requirements.

B. Accessibility: C02, C04, and CCA components shall be accessible without removing other equipment in the cabinet. Replacement of faulty equipment shall not require use of specialized tools. Use removable terminal blocks.

C. Identification: Module faceplates with color-coded, slip-in labels shall be provided as follows:

1. The label shall identify module specification and labeling for I/O point identification.

2. Major devices, assemblies, and sub-assemblies shall be identified using permanent labels or markings, each of which indicates the manufacturer's catalog number and a product manufacturing date code.

D. Power: C02, C04 and CCA equipment power shall be 24 VDC derived from the TPF 125 VDC battery-backed power source. Each cabinet's power supplies shall provide power for all cabinet equipment, presuming all cabinet equipment is operating at nominal power loads with all interfaces active. Size power supplies to accommodate additional 25 percent spare power loads for future expansion.

E. Cooling: Each cabinet's air-cooling equipment shall maintain cabinet's internal temperature at maximum 85 degrees Fahrenheit presuming all cabinet equipment is operating at nominal power loads with all interfaces active. Calculations shall account for additional 25 percent spare air-cooling capacity for future expansion.

F. Flammability: C02, C04 and CCA equipment shall meet UL94V-0 flammability rating.

G. In addition to the equipment described in this Contract Specifications Section, various hard-wired relays shall be installed in the C02 panel as shown on the Traction Power Contract Drawings.

2.02 C02 PANEL, C04 PANEL, AND CCA CABINET CONSTRUCTION

A. The construction requirements for the C02 and C04 panels and CCA cabinets shall comply with the construction requirements of the panels and cabinets specified in Contract Specifications Section 20 70 19, Indoor Cabinets, Racks, Frames and Enclosures. C02 and C04 panels shall be floor-mounted, dual door, constructed of 14-gauge steel minimum. CCA cabinet shall be wall mounted, constructed of 14-gauge steel minimum. Minimum and maximum dimensions of the C02 panels, C04 panels, and CCA cabinets shall be as shown on the Contract Drawings.

B. Cabinet doors shall be furnished with door stops that can maintain doors in open position. Cabinets shall be furnished with air fan or air conditioning equipment where design calculation submittals demonstrate air cooling is required. For cases where air-conditioning is required, the cabinet shall be equipped with close-loop air-conditioning equipment that cools the internal air of the cabinet while keeping ambient air outside of the enclosure.

C. C04 Panel Swing-out Racks

1. C04 panel's swing-out rack shall be of sufficient strength to perform the rack's swing-out functions while carrying the weight of corresponding equipment, cabling and wiring mounted on the swing-out rack and shall account for additional 25 percent spare for future expansion.

2. C04 panel's swing-out rack shall be of adequate height to inhouse racked equipment and include 25 percent spare racked equipment for future expansion.

D. C02 panel, C04 panel, and CCA cabinet's air handling equipment shall provide air handling equipment trouble alarms annunciated in ICS and EBP at BART OCC and at NYMS as applicable.

2.03 C02 PANEL, C04 PANEL, AND CCA CABINET GROUND BUS

A. A continuous ground bus of electrical-grade copper ground bar with a minimum cross section shall have area equivalent to 1/4-inch by 1-inch, shall extend across the back of each panel, and be effectively bonded to the panel/cabinet, base rail, mounting channel, and enclosure.

B. A two-hole pressure connector for #2 AWG wire shall be located at each end of the ground bus for connection to the station ground.

2.04 C02 MIMIC PANEL

A. Mimic Bus

1. Use anodized aluminum or plastic sheeting for the mimic bus. Submit the size and proportions of the figures and the overall mimic bus layout for District approval.

2. Changes and replacements shall be permitted for mounting, but screws, rivets, and bolt heads shall not show on the panel faces or the face of the mimic bus.

3. Colors shall be blue for high voltage components rated above 34.5 kV, black for the 34.5 kV components, red for the 1,000 VDC components, and green for grounding switches and components. Mimic bus colors shall be uniform and vivid.

4. The outline, surface, and finish of the mimic bus shall be smooth, without irregularities or blemishes.

5. Thickness of lines shall be 1/4-inch for 1000 VDC feeders, 1/2-inch for contact rail, and 3/8-inch for remaining components.

6. The mimic panel shall clearly differentiate between circuits of different facilities. For example, the mimic panel at a switching station shall indicate which equipment and circuits belong to the switching station and which belongs to the connecting high voltage substation.

B. Control and Selector Switches

1. Control and selector switches shall be provided as indicated on the Contract drawings.

2. Rotary operated switches:

   a. Switches shall be of the rotary, cam-operated type, suitable for panel mounting with a rectangular, front panel engraved escutcheon plate showing the switch positions.

   b. When used for circuit breaker control, switches shall have pistol-grip handles and shall be spring-return to neutral type.

   c. When used for local-remote transfer selectors, switches shall have oval handles.

   d. When used for lockout relays, switches shall have pistol grip handles.

3. Push button switches:

   a. Switches shall be square or round with a width or diameter no less than 3/4-inches and no more than 1-1/2-inches.

   b. Switches shall have a raised bezel to prevent unintended activation.

c. When provided with an integrated indicator light, the contacts for the light shall be electrically isolated from the contacts for the switch.

4. Switch contacts shall be silver-plated, self-cleaning, and shall have adequate insulation and contact surface. Switches shall be installed so that mating contact surfaces are parallel.

5. Switches and pushbuttons shall be correctly rated for the application.

C. Indicating Lights

1. Indicating lights shall use LEDs. The LEDs shall be replaceable, with built-in resistor and high dielectric strength for reverse voltage protection. The LEDs shall be:

a. Suitable for use with the DC control system voltage that is provided by the C02 PLC IOM.

b. Capable of operating over a voltage range from +15 to –30 percent of nominal.

c. Designed with bayonet bases.

d. Mounted in compact, rugged sockets.

e. Replaceable from the front.

2. Lenses and bezels shall be rectangular or circular, 1-3/8-inch maximum width and height and shall permit reading from oblique angles.

3. LEDs shall be rated for 100,000 hours at full voltage and shall be clearly visible at an angle of 30 degrees and at 15 feet in a fully lit environment.

2.05 PLC, IOM, DISTRIBUTED IOM, AND ETHERNET SWITCH EQUIPMENT

A. PLC, IOM, distributed IOM, and associated interface equipment shall be designed by the manufacturer in compliance with the following equipment test standards:

1. Environmental Tests:

a. Enclosure Protection: IEC 60529: IP3X (excluding the terminal blocks).

b. Vibration Resistance: IEC 60255-21-1:

1) Vibration Endurance, Severity: Class 2.

2) Vibration Response, Severity: Class 1.

c. Shock Resistance: IEC 60255-21-2:

1) Bump Test, Severity: Class 1.

2) Shock Withstand, Severity: Class 1.

3) Shock Response, Severity: Class 1.

d. Seismic: IEC 60255-21-3: Quake Response, Severity: Class 1.

e. Cold: IEC 60068-2-1: –40 degrees Celsius, 16 hours

f. Dry Heat: IEC 60068-2-2: +85 degrees Celsius, 16 hours

g. Damp Heat, Cyclic: IEC 60068-2-30:

1) 25 degrees Celsius to 55 degrees Celsius, 6 cycles,

2) 95 percent relative humidity.

2. Dielectric Strength and Impulse Tests:

a. Impulse: IEC 60255-5: Severity Level: 0.5 J, 5 kV.

b. Dielectric (HiPot): IEC 60255-5: Severity Level: 2500 Vac on contact output for 1 minute.

c. Insulation: IEC 60255-5: Severity Level: 500 V for greater than 1 minute.

3. Electrostatic Discharge Immunity:

a. IEC 60255-22-2 and IEC 61000-4-2: Severity Level 4

1) 8 kV contact discharge.

2) 15 kV air discharge.

4. Radiated RF Immunity:

a. IEC 61000-4-3: Severity Level: 10 V/m.

b. IEC 60255-22-3: Severity Level: 10 V/m.

5. Surge Immunity:

a. IEC 61000-4-5:

1) Severity Level: 1 kV Line to Line, 2 kV Line to Earth

6. Fast Transient, Burst Immunity:

a. IEC 60255-22-4: Severity Level: Class A: 4 kV, 5 kHz; 2 kV, 5 kHz on communications ports.

b. IEC 61000-4-4: Severity Level: 4 kV, 5kHz vibration resistance

7. Power Supply Immunity:

a. IEC 61000-4-11

b. IEC 61000-4-29

c. IEC 60255-11

8. Magnetic Field Immunity:

a. IEC 61000-4-8: Severity Level: 1000 A/m for 3 seconds, 100 A/m for 1 minute.

b. IEC 61000-4-10: Severity Level: 100 A/m.

9. Radiated and Conducted Emissions:

    a. IEC 60255-25

B. Ethernet switch and terminal server equipment shall be designed by the manufacturer in compliance with the following standard: IEEE 1613.

C. Contractor shall provide Ethernet hot-pluggable optical module transceivers (type SFP) and media converters to enable inter-sites, inter-building and intra-building interfaces for each Ethernet switch, terminal server interface port, and networked destination device approved by the District. These transceivers and media converters shall be of ruggedized industrial design.

1. SFPs shall be the following models or equal:

    a. TPF Inter-site interfaces and Backbone Single Mode SFP uplinks (1 Gbps/sec interfaces): GLC-LX-SM-RGD

    b. TPF Intra-site Multi-mode SFP interfaces:

        1) For TPF devices supporting 1 Gbps/sec interfaces: GLC-SX-MM-RGD

        2) Otherwise (TPF devices supporting 100 Mbps/sec interfaces): GLC-FE-100FX-RGD

2.06 C02 PANEL PLCS

A. PLCs shall comply with programming language requirements in IEC 61131.

B. PLC modules shall be mounted on a multi-slot chassis to provide space for the necessary modules, plus a minimum of three spare slots for future expansion. The chassis shall be equipped with redundant 24 VDC power supplies configured for automatic failover and shall be derived from the TPF 125 VDC battery-backed supply.

C. A minimum of 1 GB of user memory and 2 GB of storage shall be provided. Non-volatile memory shall be provided to permanently store the user program and tag data.

D. Ethernet adapter modules shall be provided to communicate with facility SCADA monitored devices over the C04 panel control ethernet switch(es) with the Control VLAN Ethernet ports on the HMI operator panel, such as MPRs, IPRs and NGDs, the ETTS logic controllers, 125 VDC battery backup system controllers, and the distributed IOMs associated with the DC main breakers. The Ethernet adapter modules shall support an independent Ethernet interface to the C04 panel maintenance Ethernet switches. Required SCADA monitored devices are shown on the Contract Drawings.

E. An interface module shall be mounted in the PLC chassis to connect the local IOMs in the C02 panel if necessary.

F. PLCs shall facilitate TPF indication and control software interfaces with OCC SCADA control servers (ICS/EBP/EBP2) over DNP3 and Modbus/TCP software protocols. For TPF located within BART yards, in addition to interfaces to the OCC, PLCs shall also facilitate TPF indications and controls software interface with the corresponding yard tower SCADA control servers (NYMS) over DNP3 or Modbus/TCP software protocols.

2.07 INPUT/OUTPUT MODULES

A. General: The connected I/O requirements, which include discrete and analog inputs and outputs, are shown in the C02 panel I/O schedule on the Contract Drawings. The number of I/O points for each IOM shall be enough to meet the connected I/O requirements plus 25 percent spares.

B. Each PLC chassis IOM shall be modular I/O plugged alongside with the PLC microprocessor, power couplers and Ethernet modules into a DIN-rail mounted terminal base (chassis) that provides connectivity to the I/O bus and field wiring. Removal and insertion under power shall enable a failed module to be replaced without disturbing the field wiring, other PLC chassis IOMs or system power.

C. Distributed IOMs (programmable IOMs (PIOMs), and External IOMs) shall be provided for remote monitoring and control of the TPF equipment located within the facility site, such as transformers, rectifiers, and external I/O interface modules. PIOMs shall be powered by a dedicated DC power supply circuit and shall have dual fiber optic Ethernet adapters supporting two IP-addressable logical ports. PIOMs shall be galvanically insulated from the PLC. One port shall independently serve Control VLAN and the second port shall serve Maintenance and Engineering VLAN. For devices that support only a single (not dual) IP-addressable physical port, when approved by the District, it is acceptable to implement the Maintenance and Engineering VLAN interface utilizing the devices' spare serial ports and terminal server equipment. For such cases, to enable galvanic isolation, this interface shall be done over the fiber optic media using, where necessary, fiber optic media converters at the origin and destination of the interface.

D. Discrete PLC Chassis Input Modules: Discrete input modules shall use high impedance inputs. Each module shall be rated for 24 VDC sourcing and shall provide input filtering and optical isolation. An input LED shall indicate the status of the corresponding input.

E. Discrete PLC Chassis Output Modules: Discrete output modules shall provide DC dry contact outputs as required. Contact rating shall be minimum 2 A continuous at 24 VDC and shall be powered from a 24 VDC power supply. An output LED shall indicate the status of the corresponding output.

F. PLC Chassis Analog Output Modules: Analog output modules shall employ a digital to analog converter to produce a 4 to 20 mA signal with an output resolution of 15 bits plus sign and an accuracy of 0.1 percent full scale. If digital panel meters are used, analog output modules are not required.

G. PLC and microprocessor control equipment shall be protected from damaging system potentials through use of optically isolated inputs and dry outputs.

H. PLC interfaces for the devices, controllers, houses, and cabinets located outside of the facility house with the C02 Panel or for cabinets with the ground isolated from the ground of C02 panel shall be implemented via fiber optic interfaces. However, when the manufacturer design of the outdoor device does not support fiber optic interface, as an exception, and with District approval, copper interfaces to the PLC IOMs may be allowed. For such interfaces, the copper terminations shall be protected by surge protection equipment specifically designed for such purpose and shall be submitted to District for approval.

I. C02 panel shall be inhouse standalone IOMs associated with TPF backup control system to provide a secondary independent fiber optic interface between C02 mimic panel local controls and TPF breakers. TPF backup control system serves as redundant means of breakers' monitoring and control in case of the failure of TPF Control Ethernet switch, PLC, associated modules and associated communications path components. BIOMs shall be installed in the C02 panel and matching pairs shall be installed within the AC and DC switchgear lineups. Manual local control of breaker shall be provided from the C02 mimic panel when each of the following is met:

1. The C02 main SCADA PLC, C04 control Ethernet switch, or their communications interfaces are inoperable

2. The C02 local/remote selector switch is in the LOCAL position

3. The breaker to be controlled is in CONNECTED position

4. BIOMs shall be SEL 2505 or equal. Time required for data transfer between connected BIOMs shall be less than or equal to 13 milliseconds at a Baud rate of 19,200.

2.08 PLC CHASSIS ASSEMBLY EQUIPMENT

A. C02 communication with existing BART OCC communications equipment shall be implemented through an Ethernet link from the C04 panel control network switch(es) that manage(s) the Control VLAN to the PLC located in C02 panel. The design of the PLC shall be modular, where each module shall be installed on a backplane chassis.

B. The C02 panel SCADA PLC shall be fully integrated in-chassis, modular I/O and control solution designed for industrial applications real-time automation controller (RTAC) equipped with the following:

1. Processor and communications module(s) configured to communicate with the C04 panel's control network switches. The communications shall allow for at least two serial RS-232 interfaces and a dedicated maintenance access port.

2. Power coupler module(s) allowing PLC to be powered from the redundant power supplies.

3. Digital input, digital output, analog input, and analog output modules. The quantity of the I/O shall match the I/O count specified for the TPF with additional 25 percent spare of each type for future growth, based on final project I/O count.

4. As a minimum, the PLC shall support programming functions including user access authorization, NTP Version 3 Time Synchronization (from District-provided Master Clock), master clock time distribution among substation devices interfacing the PLC, web monitoring and configuration interface, network address translation and routing, PLC programming utilizing ladder diagram, sequential function charts, function block diagram, structured text and instruction list programming languages.

5. Additional cards as necessary to support the manufacturer's design for connection to the C02 PLC.

2.09 IOM, DISTRIBUTED IOM, CONTROLLER AND PROTECTION RELAY EQUIPMENT INTERFACES

A. Each IOM, distributed IOM (PIOM), TPF controller, and protection relay shall be equipped with dual Ethernet communication ports with two physically independent, IP-addressable logical ports as specified in the equipment Contract Specifications and as specified herein. This equipment shall be configured to communicate with the C02 PLC on the primary logical communications port. The remote maintenance workstation shall be configured on the secondary logical port as indicated and as specified herein. For SCADA monitored devices that support a single (not dual) IP-addressable physical port, when approved by the District, it is acceptable to implement the Maintenance and Engineering VLAN interface utilizing the devices' spare serial ports (or USB serial port) and terminal server equipment connected to the Maintenance VLAN switch. For such cases, to enable galvanic isolation, this interface shall be done over fiber optic media, using, where necessary, fiber optic media converters at the origin and the destination of the interface.

B. Each IOM, distributed IOM, external IOM, PIOM, BIOM, TPF controller and protection relay shall be equipped to report a health trouble alarm and, where applicable, a communication trouble alarm. Each Ethernet switch, terminal server, and power supply within the TPF shall be equipped to report a health trouble alarm. These alarms shall be reported either directly to the TPF C02 PLC or to the closest IOM, PIOM, TPF controller, or protection relay capable of reporting these alarms to TPF SCADA. Alarm wiring shall maintain galvanic isolation between various TPF compartments. Criticality of failure of each device shall be determined. Each device shall be capable of reporting health trouble alarms to TPF SCADA OCC, activating direct equipment protection trips, and alerting TPF personnel. The Contractor shall propose means of protecting personnel, TPF equipment, and mitigation for approval by the District.

C. Typical I/O points associated with each equipment type specified herein are shown in the Contract Drawings and shall be finalized during the design process in coordination with the District.

2.10 C02 HMI OPERATOR PANEL

A. The C02 HMI operator panel shall consist of a conventional LCD monitor, an industrial computer, a keyboard and mouse with necessary accessories and cables.

B. The computer shall have endpoint agent installed, shall comply with DOTI Network Security Policy, shall use error correcting memory with a minimum of RAID level 1, shall have no moving parts, and shall be designed to run continuously. The computer shall be equipped with a minimum of 8 GB of RAM and a solid-state drive with a minimum of 128 GB. Power supply input shall be derived from the 125 VDC power supply. The computer shall include a DVD-RW drive and at least 2 USB ports (to serve the keyboard and the mouse). The computer shall report to the Control VLAN.

C. The monitor shall be a 32 inch, minimum, color LCD, rack-mounted unit.

D. Keyboard and Mouse: A multifunction keyboard and a USB optical wheel mouse, connected to the computer with cables. The keyboard and mouse shall be mounted on a rack drawer as shown on the Contract Drawings.

E. Operating system: The operating system shall be of the latest version Windows, Linux or other reputable software vendor with the software life support expectancy of at least 15 years. The operating system shall comply with DOTI Network Security Policy, and shall have endpoint agent installed. The type of C02 HMI operating system shall require approval by District. Except for the keyboard and the mouse, the operating system shall be configured to prevent connection of any external removable devices and external authentication devices.

F. Equipment that is functionally equivalent may be used if approved by the District.

2.11 C04 COMMUNICATIONS NETWORK PANEL

A. The C02 panel PLC and the remaining facility devices shall communicate between each other and to the BART headend equipment (via C04/CCA Ethernet switches fiber uplinks to the closest train control room (or, where applicable, maintenance yard tower)) through the C04 communications network panel. The C04 panel shall provide for traction power facility SCADA control and indication system network interface. The C04 panel shall provide for a traction power facility Maintenance and Engineering network interface. The C04 panel shall enable internal facility fiber optic communications via fiber optic cable between facility devices and shall enable fiber optic uplinks from the SCADA control and indication system, security, telephone, and the ETTS subsystems to the closest train control room.

B. The C04 panel shall provide housing for fiber optic and CAT6A patch panels, Ethernet switches, and redundant power supplies. Unless approved by the District, the C04 panel shall be a separate standalone cabinet. The C04 cabinet equipment shall be implemented as a swing-out rack to make equipment easily accessible from the front, side, and back without assembly or disassembly of the C04 rack equipment. It shall maintain horizontally level shape when positioned closed. The swing-out rack shall be a heavy-duty, at minimum 300 lbs. capacity 19 inches fully enclosed server rack with welded side hinges, gland plates, top fans, and at minimum 30 inches depth. Vertical rack unit space shall be determined by the equipment load plus 25 percent spare capacity at each TPF. The minimum rack units (RU) height shall be at least 12RU. The rack should have a locking front and locking rear that immobilizes the swing-out rack into the rear mounting plate. When

fully loaded with switch gear, power supplies, and terminal server appliances, the rack shall not deform in any direction when locked to the rear mounting plate.

C. The C04 rack shall be equipped with vertical and horizontal cable management and storage equipment for routing and mechanical protection of fiber optic and other networking cabling and maintain cable minimum bend radii requirements. The C04 panel shall be equipped with a fiber optic storage shelf and necessary storage hooks to allow storage of extra coiled fiber optic cabling, maintain cable minimum bend radius requirements, and prevent cable mechanical strain. Velcro wraps shall be used for securing cables in place. Tie wraps are not permitted. The routing of communications cabling shall provide for a physical separation from any power wiring.

D. Each Ethernet switch or switch stack in the C04 panel shall be configured to support a single VLAN:

1. Control VLAN: Provides control and remote monitoring functionality to the integrated control system (ICS) and emergency backup panels (EBP/EBP2) (and, if necessary, to New Yard Management System (NYMS)) over DOTI Network.

2. Maintenance and Engineering VLAN: Provides DOTI Network access for maintenance related data such as parameter settings, analog data, and historical logs.

E. Each Ethernet switch in the C04 panel shall be configured to support RADIUS authentication with the BART central RADIUS server.

F. The C04 Ethernet switches shall be defined as:

1. Control Switches: These switches shall support the Control VLAN.

2. Maintenance Access Switches: These switches shall support the Maintenance and Engineering VLAN.

G. C04 communications network equipment and associated cabling shall provide an Ethernet-based communications links between the C02 panel PLC, the C02 operator’s panel, the Ethernet ports on the HMI operator panel, and facility SCADA monitored equipment such as MPRs, IPRs, rectifier controller, transformer controller, the NGD controller, the PIOMs, the ETTS logic controller, and, if applicable, the 125 VDC battery backup system controller. The MPR, IPR, rectifier, transformer, PIOMs, ETTC, battery controller and NGD shall be configured to have physically separate, non-bridgeable network connections on the Control VLAN and the Maintenance and Engineering VLAN. All such Ethernet interfaces between C02 panel, C04 panel, and any other external cabinets/panels shall be implemented over the fiber optic media. The Ethernet protocol shall conform to open standards. Acceptable protocols include DNP3 and Modbus/TCP.

H. Ethernet switches shall be industrial grade devices with full IEEE 1613 and IEEE 802.3 compliance equipped with the required number of 10/100/1000-Base-TX ports, 100Base-FX ports, or 1000Base-SX ports plus 25 percent spares and two dual purpose fiber optic uplink ports. The switches shall be rack-mounted. LEDs shall be provided to display link status and activity on each port as well as power on/off status. Input power shall be 24 VDC power source, derived from the 125 VDC facility battery-backed power. Trouble alarm dry contact outputs shall be provided in front of Ethernet switches.

I. Any switch that connects to the existing systemwide Cisco network shall use passive cooling, have no moving internal parts in the switch chassis, be equipped with redundant 24 VDC power input, and have remote stacking capabilities at no less than 20 Gbps aggregate throughput via redundant fiber optic channels, RADIUS authentication, and management via an industry-standard encrypted command-line interface. The supported uplinks back to the DOTI Network station switches shall be dual-connected physical links using link-aggregation. Switches shall all be running identical firmware current to latest stable release at time of switch purchase. Switches shall be Cisco IE-5000-12S12P-10G, Alcatel-Lucent Enterprises Omni Switch 6560, or equal. Due to density requirements of each substation, the switch shall support no less than 12 SFP connections in situations in which fiber-optic connections are required to endpoint devices, and 12 gigabit PoE+ connections when copper connections are required. The quantity of the Ethernet switches shall be defined by the quantity requirements of the copper and fiber optic ports of the TPSS security networked devices plus 25 percent spare ports of each type. This shall also account for the dedicated maintenance access port for local programming of each switch. The Ethernet switches shall be equipped with the corresponding ruggedized SFPs made by Cisco, Alcatel Lucent, or equal to match bandwidth, wavelength, fiber type, length, and connector requirements of the fiber optic interfaces for each TPSS and external uplink device connected to the TPSS Ethernet switches. Equipment requiring 100 Mb bandwidth at 850 nanometers is not acceptable. Where the port count requires use of multiple switches per VLAN, the Ethernet switches for that VLAN shall form an independent stack with two redundant fiber optic backbone uplinks (to the closest TCR) per each stack. Additionally, for redundancy, each equipment racks shall include an additional spare Ethernet switch matching the operating Ethernet switch with the maximum quantity of the fiber optic SFPs and copper ports in the rack.

J. Single and multiple Ethernet switch configurations shall be implemented as follows:

1. Single Non-stacked Switch Configuration: One uplink, implemented with two fiber strands, to the train control room (or, where applicable, maintenance yard tower) shall be configured on each VLAN switch. A spare control switch shall be racked and configured, but not powered up.

2. Stacked Ethernet Switch Configuration: Two uplinks to the train control room shall be formed for the stack. First uplink to the train control room (or, where applicable, maintenance yard tower) shall be connected to the first switch. The second uplink to the train control room (or, where applicable, maintenance yard tower) shall be connected to the last switch. A spare control switch shall be racked and configured, but not powered up.

K. If 24 VDC power is not available from the facility, C04 Panel shall be equipped with redundant 24 VDC power supplies powered by the battery backed 125 VDC power. The 24 VDC power supplies shall be rated for at least 150 percent capacity of the power requirements of the C04 panel equipment. Power and link status LEDs shall be provided on the front panel. The power supply and terminal block equipment shall be DIN rail mounted.

L. C04 communications network cabling equipment shall enable physically independent fiber optic uplinks between the following equipment and the closest train control room or maintenance yard tower:

1. C04 Cabinet: Control Ethernet switch uplinks.
2. C04 Cabinet: Maintenance and engineering switch uplink.
3. CCA Cabinet: Security Ethernet switch uplink.
4. CCA Cabinet: VOIP Ethernet switch uplink.
5. ETTC Cabinet: ETTS emergency trip and transfer trip fiber-optic interconnects to other TPFs.
6. Fire Alarm Panel: BART fire alarm system surveillance uplink.

M. C04 communications network cabling equipment shall enable physically independent fiber optic links from the C02 mimic panel local control IOMs (associated with the substation backup control system) to the matching IOMs at the substation breakers.

N. Serial port terminal server shall be a ruggedized, 19 inch rack-mountable 1U solid state serial port aggregation appliance. This appliance shall be capable of a minimum 100Mb SFP Ethernet connection via multi-mode fiber. This appliance shall support industry standard encryption over Ethernet and be remotely manageable via secure command-line and web-based access methods using RADIUS authentication. The terminal server shall be Schweitzer, SEL-3610 Port Server or equal.

2.12 FIBER OPTIC, CATEGORY 3 AND CATEGORY 6A CABLES, AND PATCH PANELS

A. Unless specifically noted otherwise, fiber optic, Category 3 and 6A cables, patch panels, jumper cables, protection equipment and related accessories shall conform to the corresponding implementation and testing requirements of the TIA-455-C, TIA 455-13, TIA-526-7-A, TIA-526-14-C, TIA-568.0-E, TIA-568.1-E, TIA-568.2-D, TIA-568.3-D, TIA-569-C, TIA-606-C, and TIA-607-D standards. See Contract Specifications Section 27 13 01, Communications Cables and Equipment for additional requirements to this equipment.

B. District will provide cable number for communication cables. Communications cables shall be labeled at each end with the following information: Cable number, from, to, type of cable (e.g. 24 SM), installation date.

C. Unless noted otherwise, jumper and patch cord cables shall be labeled at each end with the following information: from, to, and jumper function.

2.13 PANEL METERS

Panel meters may be analog or digital type. Analog meters shall have a minimum four-inch circular display diameter and accept a 4 to 20 mA input. The scale shall match the measurement span and the units shall be displayed on the faceplate. Digital panel meters shall be equipped with an Ethernet port. Panel meters shall display 34.5 kV left and right cable voltages, DC bus voltage, TRU 1 (DC) amps, and TRU 2 (DC) amps.

2.14 SECURITY NETWORK COMMUNICATION PANEL (CCA CABINET)

A. A CCA cabinet shall be provided for TPF security network and VOIP phone network interfaces. These network interfaces shall enable the following:

1. TPF Security Network: TPF security devices, such as CCTV cameras, access control panel, access control panel intelligent power supply and intrusion detection panel shall report their status to the M&E security headend security office equipment via the CCA cabinet dedicated security Ethernet switch. Additionally, the CCA cabinet security Ethernet switch shall provide PoE/PoE+ power to the CCTV devices. The CCA panel Ethernet switch shall provide for an intra-facility uplink of the security interfaces to the closest train control room (or, where applicable, maintenance yard tower) via the traction power facility C04 panel's FPP.

2. VOIP Phone Network: TPF emergency and IP telephones shall provide for the TPF phone services via the CCA cabinet dedicated VOIP phone Ethernet switch. Additionally, the CCA cabinet VOIP Ethernet switch shall provide PoE/PoE+ power to the VOIP equipment. The CCA panel VOIP phone Ethernet switch shall provide for an intra-facility uplink of the VOIP phone interfaces to the closest train control room (or, where applicable, maintenance yard tower) via the traction power facility C04 panel's FPP.

B. The CCA cabinet shall provide housing for a CAT6A patch panel equipment, Ethernet switches, analog VOIP gateways if applicable, vertical and horizontal cable management equipment, and, where specified herein, redundant power supplies. The CCA cabinet shall be lockable.

C. The CCA cabinet shall be equipped with vertical and horizontal cable management equipment for routing and mechanical protection of fiber optic and other networking cabling and maintain cable minimum bend radii requirements. The CCA cabinet shall be equipped with necessary storage hooks to allow storage of extra coiled fiber optic cabling, maintain cable minimum bend radius requirements, and prevent cable mechanical strain. Velcro wraps shall be used for securing cables in place, tie wraps are not permitted. The routing of communications cabling shall provide for a physical separation from any power wiring.

D. The security network Ethernet switch in the CCA cabinet shall be configured to support DOTI Network Security VLAN and identified as a security switch.

E. The VOIP phone network Ethernet switch in the CCA cabinet shall be configured to support DOTI Network VOIP VLAN and identified as a VOIP switch.

F. The Ethernet switches in the CCA Cabinet shall be configured to support RADIUS authentication with the BART central RADIUS server.

G. Ethernet switches shall be industrial grade devices with full IEEE 802.3 compliance equipped with the required number of 10/100/1000 Base-TX ports (standard and PoE+ ports), 100 Base-FX ports, or 1000Base-SX ports plus 25 percent spares and two dual purpose fiber optic uplink ports. The switch shall be mounted on a standard 35 mm DIN rail with a horizontal orientation that does not sag or deform due to the weight of equipment. LEDs shall be provided to display link status and activity on each port as well as power on/off status. If 24V DC facility power distribution system is not available, input power shall be derived from the 125 VDC battery backed power source. The switches shall include dry relay contacts for trouble indications.

H. Ethernet switches shall be, equipped for redundant DC 24V power input, RADIUS authentication, and management via an industry-standard encrypted command-line interface. Due to density requirements of each substation, the switch shall support no less than 12 SFP connections in situations in which fiber-optic connections are required to endpoint devices, and 12 gigabit PoE+ connections when copper connections are required. The quantity of the Ethernet switches shall be defined by the quantity requirements of the copper and fiber optic ports of the traction power facility security networked devices plus 25 percent spare ports of each type. The Ethernet switches shall be equipped with the corresponding ruggedized SFPs made by Cisco or equal to match bandwidth, wavelength, fiber type, length, and connector requirements of the fiber optic interfaces for each TPF Ethernet switch and networked device and external uplink device connected to the TPF Ethernet switches. Equipment requiring 100 Mb bandwidth at 850 nanometers is not acceptable. The Ethernet switch shall be Cisco IE-4000-8GT8GP4G-E or equal.

I. If 24 VDC facility power distribution system is not available, input power shall be derived from the 125 VDC battery backed power source, the CCA cabinet shall be equipped with redundant 24 VDC power supplies powered by the battery backed 125 VDC power and rated at 150 percent capacity of the CCA cabinet and the corresponding CCTV camera and VOIP telephone equipment. Power and link status LEDs shall be provided on the front panel. The power supply and terminal block equipment shall be DIN rail mounted.

J. Refer to the Contract Specifications Sections 27 30 01, Telephone Systems, Section 28 10 01, Access Control and 28 41 29, Closed Circuit Television Systems for additional requirements for the TPF Telephone, Access Control and CCTV equipment.

2.15 APPLICATION SOFTWARE

A. Provide non-expiring individual and group multisite licenses as required to support all equipment provided by the Contract, and provide media and related documentation for each of the following software packages licensed to the District 90 Days prior to the start of installation of the C02, C04, and CCA panel equipment:

1. C02 and SCADA PLC configuration software and site-specific implementation backup of the PLC configuration software.

2. C02 HMI operator panel operating system software, application software, configuration software, and site-specific implementation backup of the application software.

3. Ethernet switch configuration software.

B. Upon completion of factory testing, submit application software and latest configuration, settings, firmware, including development environment, user permissions, and warranties. Software licenses shall be turned over to BART. Resubmit the above deliverables at commissioning of each TPF.

C. C02 HMI operator panel application software and development environment: The Contractor shall submit into an escrow account the proprietary source code of this software for a 20-year period. In event of the Contractor's bankruptcy, District shall be declared as a beneficiary of the proprietary source code of that escrow account.

2.16 FACTORY TESTS

A. Factory tests shall verify the correct function of each complete TPF, including equipment components and remote communication control, indication, and monitoring capabilities. Perform factory tests in accordance with the requirements specified in Contract Specifications Section 34 21 75, Traction Power Facility Factory Functional Testing and as specified below. Factory tests shall be led and conducted by the Contractor, witnessed by the District personnel and signed off by both the Contractor and the District.

B. Installation and testing of the communications cables and associated equipment described within this section shall be performed in compliance with implementation and test requirements of the TIA-455-C, TIA 455-13, TIA-526-7-A, TIA-526-14-C, TIA-568.0-D, TIA-568.0-E, TIA-568.1-E, TIA-568.1-D, TIA-568.2-D, TIA-568.2-C, TIA-568.3-D, TIA-569-C, TIA-569-D, TIA-606-C, TIA-606-B TIA-607-D, and TIA-607-C standards. Refer to Section 27 13 01, Communications Cables and Related Equipment for additional requirements for the communications cabling and equipment.

C. Perform tests of system performance on the factory floor with all switchgear and related equipment wired to each C02 panel. A typical factory test configuration is shown in Figure 1. Ensure that all TPF monitoring, protection, and control functions end-to-end response times shall not exceed the following:

1. For any command issued by the local TPF mimic panel, local C02 HMI operator panel, remote ICS workstation controller, remote EBP workstation controller, or remote NYMS workstation controller, the total communications time between issuing of the command and receipt of command by the field device shall be 1 second or less.

2. For any TPF field device, the time between device change of state and receipt of the corresponding indication by the local TPF mimic panel, local C02 HMI operator panel, remote ICS workstation controller, remote EBP workstation controller, or remote NYMS workstation controller shall be 1 second or less.

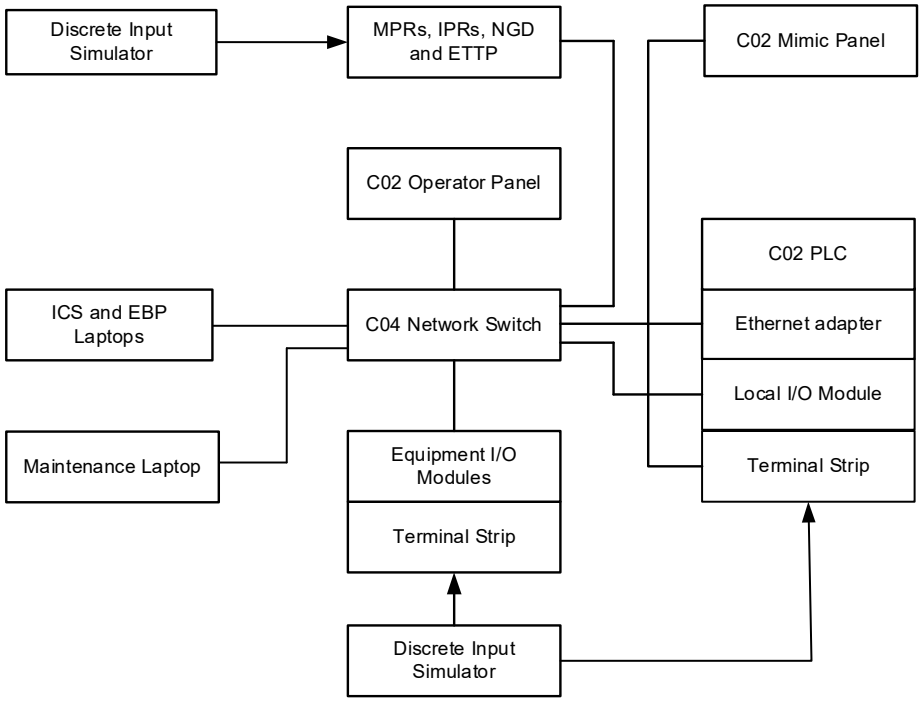


Figure 1: Example Typical Factory Test Configuration for a TPSS

D. Where possible, operate equipment to generate contact closures to the IOMs, MPRs, IPRs, PIOMs, NGD, rectifiers, transformers, ETTS, and, where applicable, battery controller. In cases where inputs must be simulated, use a discrete input simulator connected to the IOMs, MPR, IPR, rectifier, transformer, PIOM, NGD, and ETTS I/O interface to simulate the input needed. Verify discrete inputs by observing the status change on the mimic panel and/or the C02 display panel as applicable.

E. Discrete outputs to equipment shall be verified by observing equipment status change on the individual breaker display panels and the LEDs on the discrete output cards. All C02 operator panel display functions shall be demonstrated.

F. Verify the proper operation of real-time analog data generation and transmission over the network, such as AC currents and voltages from IPRs, and DC currents and voltages from rectifiers, MPRs and transducers. Check and verify device calibration and outputs from the C02 PLC to the meters mounted on the C02 mimic panel. Verify the data detection, processing, transmission, and display (or control initiation at the field device) meet the response time requirements identified above.

G. The Contractor-prepared I/O schedule shall be used as the basis to document the results of each I/O point test.

H. All TPF mimic panel and C02 HMI operator panel display functions shall be demonstrated.

I. Verify the proper configuration and functioning of all TPF VLANs. Verify proper functioning of time synchronization, IP routing, Ethernet switch uplink failover, where applicable, Ethernet stacked switch functionality, remote Maintenance and Engineering diagnostics and all other network related functions enabling proper functioning of the TPF devices. Verify from Security VLAN access to the CCA Ethernet network switch and Security VLAN network devices. Verify proper operation of the CCA cabinet VOIP Ethernet network switch, and the associated VOIP VLAN network devices including the TPF emergency and IP telephones.

J. District will supply the Contractor with a computer containing test programs that will simulate the central ICS and EBP (and where necessary, NYMS) connections. The Contractor shall use the District furnished test computer to formally verify and witness signed off proper operation of available indications and proper execution of available commands from this test program.

PART 3 – EXECUTION

3.01 SOFTWARE CONFIGURATION

A. General: Configure the software and firmware of digital and network devices to meet the functional requirements as specified herein and as approved by the District.

B. All communication to ICS, EBP, and NYMS shall be normalized. “1” shall be logic “true” for each I/O point reported to these systems and “0” shall represent logic ‘false’ for the I/O point. This shall remain the case for points that need to be wired in a “fail-safe” (normally-closed) manner, requiring an additional step to normalize the data prior to sending it to ICS, EBP, or NYMS.

C. Configure the C02 PLC as follows:

1. Perform necessary monitoring and control requirements for traction power and ancillary equipment in each TPF, including the data transfer requirements between the C02 PLC, the C02 operator panel, the C02 mimic panel, the ETTS, and the SCADA PLC.

2. As applicable for each TPF, the 34.5 kV AC circuit breaker, transformers, rectifiers, PIOMs, NGD, DC buses, DC switchgear and third rail interconnects schematic reference diagrams present the C02 panel’s monitoring and control requirements in a hardwired format. Configure C02 software to provide network and functional requirements as shown on the Contract Drawings and as specified herein.

3. The minimum monitoring and control requirements for traction power equipment are shown on the Contract Drawings. The monitoring requirements for specified ancillary equipment such as AC and DC power supplies including the battery system, HVAC equipment, fire alarm systems, intrusion detection systems, radio system, and other systems, shall be as specified in the related Contract Specifications Sections. All monitored devices shall be connected via Ethernet or hardwired connection to the applicable C02 network IOM.

4. The PLC shall communicate with networked devices on Control and Maintenance VLANs via the Ethernet TCP/IP network.

5. The C04 panel Ethernet switch shall be linked to the SCADA PLC in the C02 panel that communicates with ICS and EBP at the OCC, and if applicable, shall be linked to the yard TPFs that communicate with the NYMS, via the DOTI Network. All communication to ICS, EBP, and NYMS shall be normalized. “1” shall be logic “true” for each I/O point reported to these systems and “0” representing logic “false” for the I/O point. This shall remain the case for points that need to be wired in a “fail-safe” (normally-closed) manner, requiring an additional step to normalize the data prior to sending it to ICS, EBP, and, if applicable, NYMS.

6. Submit to BART the Device IP Address Schedule template table provided in the Contract Drawings containing the list of all TPF IP-addressable devices and physical and logical network topology diagrams at least 60 Days prior to submittal of the factory test plan. District will assign the desirable IP addresses and submit it back to the Contractor for implementation. District will supply the template configuration files for the TPF Ethernet switch equipment for Contractor implementation.

D. Configure the TPF network switches to provide connectivity between all TPF network devices including uplinks to TCRs per approved network diagrams.

E. Configure the HMI operator panel displays shown in the Contract Drawings and as specified below:

1. The design of the displays in terms of display interaction and navigation, use of colors and pop-up displays shall be based on the guidelines provided in ISA101. The overall display hierarchy is shown in Figure 2 and some typical lower level displays are shown on the Contract Drawings as a guideline. The menu bar shown on the lower level of the Contract Drawings shall be provided on the top-level display.

2. The top-level display, which shall be also the default screen, shall be based on the associated hardwired mimic display layout but without any control capability. Voltage and current values shall be displayed. The following color conventions shall be used:

   a. Circuit breaker symbols: Closed – Red; Tripped – Green

   b. High voltage above 34.5 kV: Active – Red; Inactive – Green

   c. 34.5 kV AC Cables and Busses: Active – Red; Inactive – Green

   d. 1000 V DC Cables and Busses: Active – Red; Inactive – Green

3. Current Equipment Status Displays: A Current Equipment Status display shall be provided as shown on the Contract Drawings.

4. Current Network Status Displays: A Current Network Status display shall be provided as shown on the Contract Drawings.

5. Alarm Summary Displays: Two alarm summary displays, Current Alarms and Alarm History, shall be provided as shown on the Contract Drawings. Clicking on a blinking breaker symbol shall display the Current Alarm display. Clicking on the blinking point ID shall display a pop-up to permit acknowledgement of the alarm. The point ID shall change to steady when the alarm is acknowledged. New alarms shall cause the “current alarms” icon to blink and when selected, bring up the current alarm display as previously described. When an alarm returns to normal, it shall be transferred to the Alarm History display. On both displays, arrange the alarms in chronological order with the most recent alarm on top. Provide capability to filter or search by alarm type and date range for specific alarms in the alarm history log.

6. An ICS Control Status and Test screen shall include an annunciator-like display that shows all current indications being sent to the central system via the C02 panel PLC. Pulsed commands arriving from the C02 panel PLC from the central ICS system shall be displayed and held long enough for the maintainer to confirm receipt of the command.

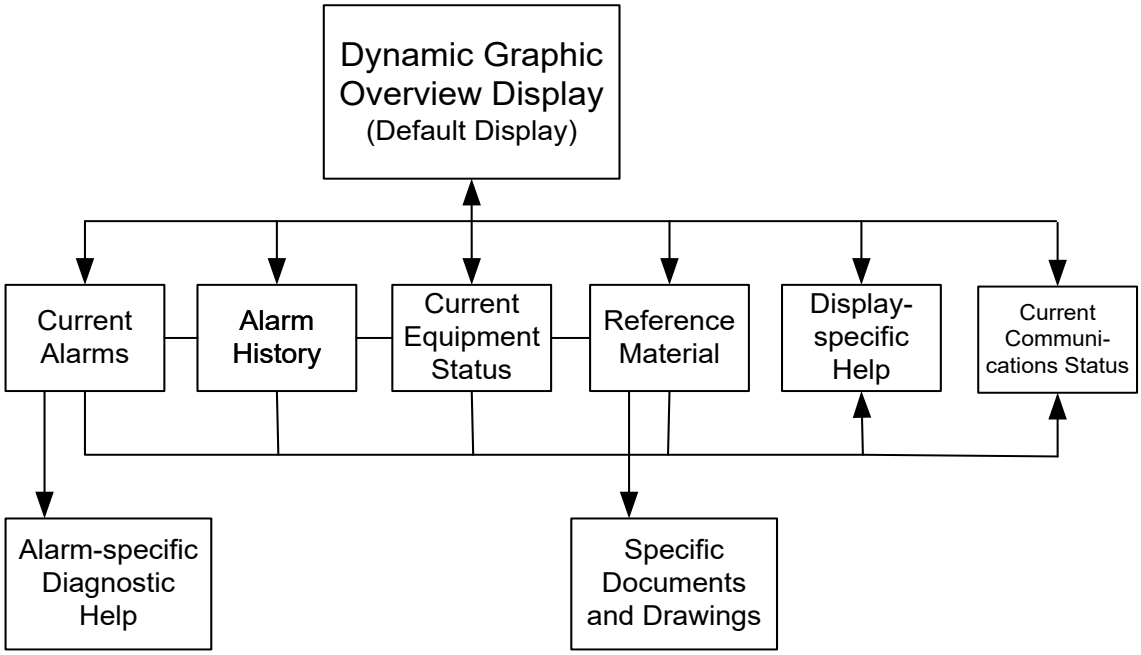


Figure 2: CO2 Operator Panel Display Hierarchy

7. Convert all traction power facility manuals and drawings to PDF format and store on operator panel solid state drive for online access. Provide keyword search for all stored documents. Organize the Reference Material display to match the accessible content.

8. Incorporate a Help display for each page to explain how the user performs all available functions. Include Help screens, which clearly depict anticipated colors, blinking aspects, variety of the devices displayed icons and their corresponding meaning for the end user. In addition, provide a link between each alarm point ID and the appropriate O&M manual reference to aid in troubleshooting and correction of the alarm condition. Use the right mouse button to access the point-specific diagnostic reference material.

9. If a subordinate display is inactive for “x” minutes, the overview display shall be automatically re-displayed.

10. The operator panel shall automatically turn off after an adjustable time and shall immediately be re-activated by touching a key on the keyboard or the mouse. The initially set default setting shall be 30 minutes.

F. C04 Panel Ethernet Switches: Configure as follows:

1. Control Switches: These switches shall enable the Control VLAN, the data acquisition and control requirements of the C02 PLC as shown in the C02 panel I/O schedule on the Contract Drawings.

2. Maintenance Access Switches: These switches shall enable the Maintenance and Engineering VLAN for access to MPR, IPR, PQMs, rectifier, transformer, NGD, and ETTS logic controller maintenance data.

G. C02 Panel PLC:

1. Configure the C02 panel PLC to communicate bi-directionally with the C02 PLC I/O point data base.

2. Configure the C02 panel PLC to communicate bi-directionally with the central ICS and EBP systems at the OCC, and, if applicable, with the NYMS system. District will provide the Contractor with a sample I/O tag list, based on SCADA points shown in the Contract Drawings, that the Contractor shall use as a guide for format and naming conventions. The Contractor shall provide District with a final District approved list of I/O tags for the specific breaker configuration of each location. District will review and return within 21 Days a PLC software module that will interface to the ICS, EBP, and, if applicable, NYMS systems. It is the responsibility of the Contractor to integrate this into the C02 panel PLC code and test the interface.

3. The Contractor shall provide District with the final source and object code used for each location in electronic form.

H. CCA Cabinet Security Ethernet Switch: Configure the CCA cabinet security Ethernet switch to enable Security VLAN communications for the TPF CCTV and access control equipment.

I. CCA Cabinet VOIP Ethernet Switch: Configure the CCA Cabinet VOIP Ethernet switch to enable VOIP VLAN communications for the TPF emergency and IP telephone equipment.

3.02 DOCUMENTATION AND SOFTWARE

A. Submit for District approval documentation of the configuration of the C02 panel, C04 panel, and CCA cabinet equipment, including SCADA PLCs, IOMs, Ethernet switches, C02 HMI operator panel, and all other TPF devices communicating over the Ethernet network including system configuration block diagrams, functional descriptions, inter-connection diagrams, IP address and VLAN assignments, user names and passwords, hardware configuration settings, dip-switches, firmware versions, electronic backups of the application backups for all modules above, and a site-specific I/O schedule that conforms to the layout provided in Figure 2. In addition, the Contractor shall supply the electronic backups of the following:

1. C02 panel SCADA PLC configuration software and site-specific implementation backup of the PLC configuration software.

2. C02 HMI operator panel operating system software, application software, configuration software, and site-specific implementation backup of the application software.

3. Software requested in Contract Specifications Section 34 21 01, General Requirements for the Traction Power System, Article 1.23.C.

4. Submit materials described in paragraph 3.03.A following field acceptance testing. Submit as-built versions of materials described in paragraph 3.03.A prior to Contract close out.

B. Supply hardware operation and maintenance documentation, including:

1. Operations and maintenance manuals for all supplied equipment.

2. Diagnostic manuals for troubleshooting all supplied equipment.

C. Supply all documentation and software in hard copy form and on a USB drive.

3.03 WORK PERFORMED BY BART

A. To enable implementation of TPF inter-sites and backbone uplink fiber optic runs, the Contractor shall be responsible for furnishing and routing of all new cable runs and the corresponding supports, conduits and pathways at TCRs or communication equipment rooms. The new and existing cables at such locations shall be left unterminated and coiled above existing operating BART cabinets. District will be responsible for routing all such coiled cables into the operating BART cabinets and their termination. Contractor shall be responsible for furnishing fiber optic jumper equipment to be installed inside existing operating BART cabinets. District will be responsible for installation of such cross-connect fiber optic jumper equipment inside the cabinets. This work will enable backbone uplinks for each TPF Ethernet switch to the DOTI Network and ETTS fiber optic runs to the adjacent TPFs.

B. Install Contractor-furnished Ethernet hot-pluggable optical module transceivers (SFP type) in TPF-adjacent train control room or communications equipment rooms. These SFPs will be used for the TPF's Ethernet switches backbone fiber optic uplinks for connections between TPF's and existing DOTI Network Ethernet switch equipment inside existing BART operating network cabinets in TCRs or communications equipment rooms.

C. Configure the following workstation displays:

1. The existing ICS at the OCC.

2. The existing EBP at the OCC.

3. Where applicable, the existing NYMS at the yard control tower.

D. Implement Ethernet connection between TPF Ethernet switches and existing maintenance workstations used to access TPF equipment maintenance data. Prior to the beginning of the commissioning phase of the TPF (see the description of field testing phases below), the TPF network connection to the DOTI Network will be enabled and District staff will program the TPF switches with BART security settings. Contractor will no longer be able to access and change the TPF Ethernet switch configuration.

E. Based on the Contractor network diagram and listing submittals (see Article 1.07.D), District will furnish the Contractor with IP addresses and VLAN numbers for TPF networked equipment. These network settings shall be programmed by the Contractor and shall be used in all stages of testing. Based on the IP addressing and VLAN numbers provided by District, Contractor shall update the original design submittals and resubmit for the final approval. Final submittal shall include line-level diagrams specifying the physical port and assigned IP address of each device and switch, and switch configuration files that will be used for all stages of testing.

3.04 FIELD TESTING

A. Submit recommended field test procedures for use by others in accordance with Contract Specification Section 34 21 80, Traction Power System Field Acceptance Testing.

B. Field installation and testing of the communications cables and the associated equipment described within this section shall be performed in compliance with implementation and test requirements of the TIA-455-C, TIA 455-13, TIA-526-7-A, TIA-526-14-C, TIA-568.0-D, TIA-568.0-E, TIA-568.1-E, TIA-568.1-D, TIA-568.2-D, TIA-568.2-C, TIA-568.3-D, TIA-569-C, TIA-569-D, TIA-606-C, TIA-606-B, TIA-607-D, and TIA-607-C standards. Refer to Section 27 13 01, Communication Cables and Related Equipment for additional requirements for the communications cabling and equipment.

C. Field installation and testing of the TPF emergency and IP telephone system equipment shall be performed in compliance with the Section 27 30 01, Telephone Systems.

D. Field installation and testing of the TPF CCTV system equipment shall be performed in compliance with the Section 28 41 29, Closed Circuit Television Systems.

E. Field installation and testing of the TPF access control system equipment shall be performed in compliance with the Section 28 10 01, Access Control.

END OF SECTION 34 21 33

SECTION 34 21 35

EMERGENCY AND TRANSFER TRIP SYSTEM

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Submittal Requirements

B. ETTS Functional Requirements

C. Emergency and Transfer Trip Cabinet

D. Emergency Trip Panel

E. ETTS Logic Controller

F. ETTS Input/Output Module (IOM) and Other Equipment

G. Blue Light Stations

H. Equipment and Requirements in Existing Old TP Facilities

I. Equipment and Requirements in Train Control Rooms (TCRs)

J. Interfaces and Requirements in New Substations Provided by Others

K. Software Requirements

L. Factory Testing

M. Installation

N. Field Testing

O. Commissioning Support

1.02 RELATED CONTRACT SPECIFICATIONS SECTIONS

A. Section 01 11 00 Summary of Work

B. Section 01 33 00 Submittal Procedures

C. Section 01 33 23 Shop Drawings, Product Data, and Samples

D. Section 01 43 00 Quality Assurance

E. Section 01 45 00 Quality Control

F. Section 01 45 24 Testing Program Requirements

G. Section 01 78 23 Operation and Maintenance Data

H. Section 01 78 39 Project Record Documents

I. Section 01 79 00 Demonstration and Training

J. Section 20 50 13 Raceways for Facility Services

K. Section 20 40 13 Identification for Facility Services

L. Section 26 05 24 Low Voltage Wires and Cables

M. Section 26 05 26 Grounding and Bonding for Electrical Systems

N. Section 27 13 01 Communication Cables and Related Equipment

O. Section 27 30 01 Telephone Systems

P. Section 34 21 01 General Requirements for the Traction Power System

Q. Section 34 21 11 Multi-Function Protection Relay Equipment for DC Feeder Circuit Breakers

R. Section 34 21 25 DC Switchgear

S. Section 34 21 33 Traction Power Control, Monitoring, and Display Panel and Related Equipment

T. Section 34 21 40 DC Control Power System

U. Section 34 21 50 Common Materials and Methods for Traction Power

V. Section 34 21 70 Traction Power Facilities Installation Requirements

W. Section 34 21 75 Traction Power Facility Functional Factory Testing

X. Section 34 21 80 Traction Power System Field Acceptance Testing

1.03 MEASUREMENT AND PAYMENT

A. Measurement: Emergency and transfer trip cabinets, emergency trip panels, and blue light stations an associated wiring interfaces will be measured for payment per each unit that is tested, furnished, and installed in accordance with the Contract Drawings and Contract Specifications.

B. Payment: Emergency and transfer trip cabinets, emergency trip panels, blue light stations, and associated wiring interfaces will be paid for at the Contract unit price for each control, monitoring, and display system as indicated in the Bid Schedule of the Bid Form.

1.04 ABBREVIATIONS

A.	BLS	Blue Light Station
B.	CR	Contact Rail
C.	DC	Direct Current
D.	DIOM	Diagnostic Input/Output Module
E.	DPDT	Double Pole, Double Throw
F.	DPST	Double Pole, Single Throw
G.	EBP	Emergency Backup Panel
H.	ET	Emergency Trip
I.	ETP	Emergency Trip Panel
J.	ETS	Emergency Trip Station
K.	ETTC	Emergency and Transfer Trip Cabinet
L.	ETTS	Emergency and Transfer Trip System
M.	FAT	Factory Acceptance Testing
N.	FEC	Fiber Entry Cabinet
O.	FO	Fiber Optic
P.	LC	Logic Controller
Q.	FOT	Fiber Optic Transceiver
R.	GBS	Gap Breaker Station
S.	GRS	Galvanized Rigid Steel
T.	ICS	Integrated Computer System
U.	ID	Identification
V.	I/O	Input/Output
W.	IOM	Input/Output Module
X.	IP	Internet Protocol
Y.	LV	Low Voltage

Z.	MPR	Multi-Function Protective Relay
AA.	NC	Normally Closed
BB.	NO	Normally Open
CC.	NYMS	New Yard Management System
DD.	OCC	Operations Control Center
EE.	O&M	Operation and Maintenance
FF.	PS	Power Supply
GG.	PT	Platform Trip
HH.	PTPSS	Portable Traction Power Substation
II.	PTS	Platform Trip Station
JJ.	SCADA	Supervisory Control and Data Acquisition
KK.	SIT	System Integration Testing
LL.	SSWP	Site Specific Work Plan
MM.	TCR	Train Control Room
NN.	TETP	Temporary Emergency Trip Panel
OO.	TPF	Traction Power Facility
PP.	TPSS	Traction Power Substation
QQ.	TT	Transfer Trip
RR.	TTS	Transfer Trip System
SS.	USB	Universal Serial Bus
TT.	V	Volt
UU.	YT	Yard Trip
VV.	YTS	Yard Trip Station

1.05 REFERENCES

A. Electronic Industries Association (EIA):

1. EIA/TIA-232-F	Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange
2. EIA 310-E	Cabinets Racks, Panels, and Associated Equipment

B. International Electrotechnical Commission (IEC):

1. IEC 60068	Environmental Testing
2. IEC 60255	Measuring Relays and Protection Equipment
3. IEC 60529	Degrees of Protection Provided by Enclosures
4. IEC 61000	Electromagnetic Compatibility

C. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE C2	National Electrical Safety Code (NESC)
2. IEEE 802.3	Standard for Ethernet
3. IEEE C37.90	Standard for Relays and Relay Systems Associated with Electric Power Apparatus
4. IEEE C37.90.1	Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus

D. National Electrical Contractors Association:

1. NECA/FOA 301	Standard for Installing and Testing of Fiber Optic Cables

E. National Fire Protection Association (NFPA):

1. NFPA 70	National Electric Code
2. NFPA 130	Standard for Fixed Guideway Transit and Passenger Rail Systems

F. Telecommunications Industry Association (TIA):

1. TIA-455-C	General Requirements for Standard Test Procedures for Optical Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components

2. TIA 455-13 — Visual and Mechanical Inspection of Fiber Optic Components, Devices, and Assemblies
3. TIA-526-7-A — Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant
4. TIA-526-14-C — Optical Power Loss Measurement of Installed Multimode Fiber Optic Cable Plant
5. TIA-568.0-E — Generic Telecommunications Cabling for Customer Premises
6. TIA-568.1-E — Commercial Building Telecommunications Infrastructure Standard
7. TIA-568.2-D — Balanced Twisted-Pair Telecommunications Cabling and Components Standards
8. TIA-568.3-D — Optical Fiber Cabling and Components Standard
9. TIA-606-C — Administration Standard for Telecommunications Infrastructure
10. TIA-607-D — Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises

G. Underwriters Laboratories (UL):

1. UL 94 — Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
2. UL 595 — Standard for Safety Marine-Type Electric Lighting Fixtures

1.06 SYSTEM DESCRIPTION

General: The emergency and transfer trip system (ETTS) provides fast and reliable means of de-energizing the inbound and outbound 1000 VDC contact rail system in cases of faults or emergency. The ETTS features redundant fiber optic cable loops that interconnect logic controllers (LCs), that issue circuit breaker trip signals to quickly de-energize required contact rail sections upon activation of a wayside platform trip station (PTS) or emergency trip station (ETS). The ETTS provides a transfer tripping function whereby fault detection in one traction power facility (TPF) results in automatic tripping of the circuit breakers in other TPFs supplying the same contact rail section(s). The main system components, by type, and main functionalities are:

A. Emergency and Transfer Trip Cabinet (ETTC): These cabinets are located in traction power substation (TPSS) and gap breaker station (GBS) DC houses, and contain LCs, input/output modules (IOMs), and in the case of new or replaced TPFs, a diagnostic input/output module (DIOM) for interface with the TPF site's blue light station (BLS). The LCs shall receive and process trip signals and issue non-reclosing or auto-reclosing-enabled circuit breaker trip requests (depending on the source of the request) to DC feeder breakers to de-energize a target contact rail section.

B. Emergency Trip Panel (ETP): ETPs are located in train control rooms (TCRs). ETPs receive emergency trip signals from existing platform trip stations (PTSs) and wayside emergency trip stations (ETSs) and convey these signals through IOMs and a fiber optic cable link to an associated ETTC located in an adjacent traction power facility's DC house.

C. Platform trip station (PTS): PTS provide an emergency means of de-energizing the 1000 VDC contact rails at a passenger station platform. PTSs with pushbuttons are existing devices located on the passenger platforms of existing BART stations. PTS pushbutton activation maintains a standing trip command until the pushbutton is reset, so the circuit breakers shall be forced to remain open and the contact rail section de-energized until the PTS is manually reset. The standing PTS signal is sent to an ETP in the nearest TCR, that conveys the signal to a traction power facility's ETTC. The ETTC's LC then sends trip requests to appropriate DC feeder breakers to de-energize a target contact rail section.

D. Emergency trip station (ETS) on the mainline and in yards:

1. Mainline ETS pushbuttons are incorporated in blue light stations (BLSs) located as follows:

    a. In tunnels alongside cross-passage and exit doors, in both trainways.

    b. Emergency access to trainway, at a location inside the BART right-of-way, alongside the emergency access door or gate, except where an emergency access is within 100 feet walking distance of a trainway Blue Light Station (excepting underground Blue Light Stations), and the trainway Blue Light is within sight from the emergency access.

    c. In the underground storage and tail tracks, alongside each trainway.

    d. In storage and tail track locations, where such trainways are in open cuts. Where line storage and tail tracks are at grade or in aerial structures, Blue Light Stations are not required.

    e. In open cut trainways, alongside each trainway, in which the wall height of the cut exceeds 20 feet, and the length of the cut exceeds 1,000 feet.

    f. In turnaround tracks, alongside each trainway.

    g. In the immediate vicinity of the line maintenance pits.

    h. At traction power substations, switching stations, and sectionalizing stations just inside the main entrance gate.

2. Yard ETS pushbuttons are incorporated in blue light stations (BLSs) located as follows:

    a. At both ends of storage track arrays, and at intermediate points.

    b. At the edge of transit vehicle maintenance shop apron.

    c. At emergency access to the yard, including test track areas, except when the entrance is within 100 feet of a Blue Light Station in the yard, and that Blue Light Station is within line of sight and is not normally obscured by transit vehicles.

    d. Within 50 feet of vehicle and passenger crossings.

    e. In the yard tower and the car wash facility.

    f. Throughout the yard such that one is easily located and accessible from any location under any circumstances.

    g. At traction power substations and high voltage substations.

3. The ETSs do not maintain a standing trip command, as their pushbutton is with a spring return. Therefore, the circuit breakers supplying the de-energized contact rail may be reclosed remotely, following the ETS pushbutton release. Existing mainline ETS systems may be based on either electromagnetic relays and copper pilot wires or solid-state logic controllers and fiber optic cables. The interfaces of the existing ET system with the existing (original) TP facilities which are being replaced shall be de-commissioned, while otherwise the existing ET system along the tracks and in the TCRs shall be retained and incorporated in the new ETTS specified herein.

4. Newer ETSs on BART connected in parallel in a common trip circuit are equipped with an auxiliary contact, which is used by SCADA for identifying the ETS that has been activated. Older ETSs do not have such a contact, however, and individual ETS identification upon activation is not required for them.

5. IOMs housed in emergency trip panels in train control rooms are used to interface the new ETTS with the existing wayside ETS circuits. Each such IOM is connected via a fiber optic link to a LC in an ETTC in the nearest traction power substation. The LC initiates DC circuit breaker tripping without automatic reclosing, as needed to de-energize the target contact rail section(s). The same IOM in the ETP can be used for both the PTS and ETS interfaces.

E. ETS at a New or Replaced Traction Power Facility: An ETS pushbutton is incorporated in a BLS located in the fenced area of an above-ground TPSS or GBS, or as indicated in the Contract Drawings in the case of underground facility. The hard-wired circuit from the ETTC to the TP site ETS is supervised using a diagnostic input/output module (DIOM) in the ETTC. The circuit's integrity is monitored by circulating milliamp current through it passing also through an analog input of the DIOM; and an alarm is raised if circuit discontinuity is detected. TP site ETS activation issues:

1. Non-reclosing trip commands to the 34.5 kV AC circuit breakers of the TPSS.

2. Non-reclosing trip commands 1000 VDC circuit breakers in the TPSS or GBS.

3. Non-reclosing trip commands to 1000 VDC feeder circuit breakers in the adjacent TPFs that supply power to any contact rail sections in the vicinity of the traction power facility where the emergency trip command originates.

F. Transfer Trip System (TTS) for Short Circuit Faults: When an overcurrent device in a TPSS or GBS senses an electrical fault on the 1000 VDC distribution system, it trips its own circuit breaker and at the same time transmits a transfer trip signal via the ETTS to trip corresponding circuit breakers at adjacent TPSSs and GBSs connected to the same contact rail section, in order to ensure the de-energizing of that section. All circuit breakers should attempt to automatically reclose once the circuit breaker reclosing systems sense that the fault has been cleared. The existing TTS uses along-track pilot wires and electromechanical relays in the traction power facilities. It will be replaced by the new ETTS described herein.

1. In new or replacement TPFs, fault detection at the initiating circuit breaker will be initiated by any one of instantaneous over-current, time over-current, or current rate-of-rise protective functions (Devices 150/151) of the multi-function protective relay (MPR) of the DC feeder circuit breaker, as specified in Contract Specifications Section 34 21 11, DC Circuit Breaker Multi-Function Protection Relay; and by the direct acting series trip Device 176, as specified in Contract Specifications Section 24 21 25, DC Switchgear.

2. In existing TPFs included in the ETTS, the existing over-current type protective relaying and the circuit breakers' series trip Device 176 will be used for the TT interfaces with the new ETTS.

G. ETTS for DC Structure Alive Faults: For new or replaced TPFs, in the event of DC enclosure alive fault in the DC feeder circuit breakers detected by a Device 164 relay, the ETTS will trip open in non-reclose mode the DC feeder circuit breakers in the facility where the trip originates and in the other TPFs supplying the same contact rail sections, in order to de-energize the load side of the DC feeder breakers in the faulted TPF. Circuit breakers in the facility where the 164 is activated will also be tripped by the facility lockout relay.

H. ETTS Equipment Trouble Alarms: In new or replaced TP facilities, ETTS Equipment Trouble Alarms will be displayed on the alarm screens of the C02 panels, and sent to the BART OCC. In existing TP facilities, these alarms ae to be hard-wired to an existing SCADA circuit for remote indication to the OCC.

I. ETTS Activation Alarms: These alarms identify the source and type of a circuit breaker tripping by the ETTS. In new TP facilities they are to be sent over an Ethernet link to the control network switch in the C04 cabinet, from where they will be routed for display on the C02 panel's alarm screen and sent also to the OCC. Logic controllers in existing TP facilities are not required to report such alarms.

J. Inter-Facility Communications: ETTS communications between different facilities are to be accomplished by using the BART fiber optic cable network. The cables are single mode type, and either spare fibers in existing cables or unused new cables are to be employed for this purpose, depending on the situation.

K. See Standard Drawing TPS129 for a typical ETTS schematic diagram.

1.07 WORK OVERVIEW

A. Equipment: Provide equipment specified herein and as indicated on the Contract Drawings, including ancillary and supporting devices, to supply a fully functional ETTS comprising emergency trip and transfer trip zones as shown on the Contract Drawings. The ETTS shall incorporate the circuit breaker tripping logic for all conditions, as shown and stated in the Contract Documents. The ETTS shall generate ETTS-associated alarms, locally at TPFs and remotely at the BART OCC, as indicated.

B. Factory Testing: Factory-test each TP facility's ETTS system to demonstrate correct operation of its equipment and associated ETTS communication loop and common-to-the loop other facilities, as shown on the Contract Drawings. The factory testing shall be in accordance with the requirements of Article entitled Factory Acceptance Testing under Part 3 herein; and of Contract Specifications Section 34 21 75, Traction Power Facility Functional Factory Testing.

C. Installation: Install ETTS equipment and associated raceways and accessories in the TPSS, GBS, and TCR facilities per requirements of Article entitled Installation under Part 3 herein, and as required to implement the ETTS as defined on the Contract Documents. Coordinate with the District, and with others, as needed, to implement a complete and operational ETTS.

D. Field Testing: Field-test the ETTS as a standalone system in accordance with the requirements of Article entitled Field Testing under Part 3 herein.

E. System Integration Testing (SIT) and Commissioning: Perform SIT in accordance with the ETTS-related requirements of Contract Specifications Section 34 21 80, Traction Power System Field Acceptance Testing. Assist the District with the ETTS commissioning.

1.08 SUBMITTALS

A. General: Refer to the Contract Specifications Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Submit detailed design drawings. The drawings shall cover all equipment supplied by the Contractor, including functionality, wiring and communication interfaces, modifications to equipment in existing TPFs and TCRs, software documentation, new equipment installation, and ETTS enclosures and raceways. For parts and aspects of the ETTS for which detailed Contract Drawings have been provided, these drawings shall be re-used except for possible corrections for errors and omissions. In the case of work in existing TPFs and TCRs, the drawings shall include modifications accounting for field conditions discrepant from those indicated on the Contract Drawings. The detailed design drawings shall include the following:

1. System-wide schematic diagrams showing the ETTS communication loops, equipment and main interfaces with the TP switchgear and wayside ET systems and devices;

2. Wiring diagrams for the ETTC- and ETP-based equipment. Include wiring interfaces internal to the ETTCs and ETPs including terminal block point designations, wiring interfaces with the DC switchgear and other equipment in TP facilities, and with the existing emergency trip systems in the TCRs;

3. Detailed design drawings for modifications to existing TPFs included in the ETTS communications loops, as required to install and interface the new ETTS equipment with the existing TP equipment. Include installation design for the new equipment enclosures and raceways, installation of new devices in existing DC switchgear cubicles, and wiring modifications to existing relaying and circuit breaker controls;

4. Detailed design drawings for modifications in the TCRs used by the ETTS, including installation design for the new raceways and ETP, and the new wiring and related interfaces with the existing PTS and ETS circuits;

5. Facility-specific ETTC and ETP designs, including scaled internal equipment layouts complete with devices and wiring provisions;

6. Ethernet interface diagrams between LCs and substation C04 network equipment, LC’s communication protocols, and Ethernet IP settings;

7. ETTS I/O point schedules and alarm lists for display on the C02 panel’s alarm screen in new TPFs, and for sending to the BART OCC;

8. Fiber-optic cabling interfaces at the BART FECs in the TCRs, including assignment and utilization of fibers of existing BART cables, and interconnection details;

9. Circuit breaker trip logic tables for the TP facilities included in the ETTS;

10. ETTS logic flow charts and diagrams, documenting the application software development and operating logic for LCs and DIOMs.

11. Drawings for any required modifications to emergency trip circuits in TCRs and to equipment in existing TP facilities, associated with an interim ET system configuration. Such configurations include a TPSS taken out-of-service for replacement and its sectionalizing gaps in the contact rails jumpered across for electrical continuity; and operations with partially completed ETTS loops, as indicated on the Contract Drawings.

C. Submit equipment installation instructions.

D. Submit product data sheets with functional descriptions and technical parameters for ETTS related equipment including LCs, IOMs, DIOMs, FOTs, BLSs, fiber-optic cables, fiber-optic connectors, terminal blocks, conduits, control wiring and control cables, control relays, pushbutton switches, low voltage circuit breakers, cabinets and enclosures, and equipment mounting hardware and materials. Include:

1. Hardware reliability and performance certifications

2. Input/output characteristics

3. Selected device options, settings, and ratings

E. Submit the following design documentation:

1. Design calculations for the sizing of the resistors (in-series and end-of-line) for the supervised trip circuit from the DIOM in a TP facility's ETTC to the TP site BLS. Calculations shall include all DIOM parameter settings.

2. Design calculations for the selection of fiber-optic transceivers for the single-mode LCs, DIOMs and IOMs, and for the fiber-ready boards for the multi-mode IOMs. The design calculations and corresponding transceiver choices shall be such as while the transceivers have adequate reach, there are no optical signal reflections at the shorter distances, in order to avoid the resorting to fiber attenuators.

3. Design calculations for demonstrating that the installation of ETTS cabinets, raceways and devices meets the seismic requirements of the Contract.

4. Equipment data sheets for logic controller, IOMs, and transceivers demonstrating that equipment meets requirements noted in Article 2.02.A.

5. ETTS software code documentation for logic controllers and diagnostic IOMs, including explanatory narrative, logic diagrams, software programming code, software and hardware settings for all devices, and security passwords.

6. Replacement drawings for existing TP facilities and TCRs, where existing equipment and circuits have been modified, or new ETTS devices, cabling and raceways have been installed.

F. Warranty certifications.

G. Factory and Field Test Reports: Submit factory and field test plans, test procedures, test data forms, and test reports in accordance with Contract Specifications Section 01 45 24, Testing Program Requirements, applicable requirements specified herein, Section 34 21 75, Traction Power Facility Functional Factory Testing, and Section 34 21 80, Traction Power System Field Acceptance Testing.

H. Operation and Maintenance (O&M) Manuals: Submit O&M manuals in accordance with Contract Specifications Section 01 78 23, Operation and Maintenance Data.

I. Training Materials: Submit training materials in accordance with Contract Specifications Section 01 79 00, Demonstration and Training.

J. Record Drawings: Submit Record Drawings in accordance with Contract Specifications Section 01 78 39, Project Record Documents.

K. Spare Parts: Submit a recommended spare parts list in accordance with Contract Specifications Section 01 78 44, Spare Parts and Maintenance Materials, and per the requirements specified in Article entitled Spare Parts under Part 2 herein.

1.09 QUALITY ASSURANCE

A. Electrical components, devices, and accessories shall be listed and labeled in conformance with NFPA 70, Article 100. Electrical components, devices, and accessories shall comply with NECA's National Electrical Installation Standards.

B. Refer to Contract Specifications Section 01 43 00, Quality Assurance, and Section 01 45 00, Quality Control, for hardware quality assurance requirements.

C. Products shall be manufactured by firms regularly engaged in the manufacture of products described in this Section.

D. Field testing shall be performed by persons having five or more years of relevant testing experience.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Equipment in storage before shipment and during installations shall be protected from physical damage and from the environment.

B. Equipment shall be weatherproofed for shipment. Connection openings shall be closed to prevent entrance of foreign material during shipment and storage.

C. Material and equipment shall be delivered as completely assembled as practicable within shipping and handling limitations, ready for installation or storage per manufacturer's instructions.

D. Equipment shall be handled and stored in conformance with manufacturer's instructions. One copy of these instructions shall be included with the equipment at time of shipment.

E. Equipment in storage before shipment and during installations shall be protected from physical damage and from the environment.

1.11 WARRANTY

A. A warranty for the ETTS components shall be provided and signed by the manufacturer agreeing to correct system deficiencies and replace components that fail in materials or workmanship. The warranty shall be for the period between installation and two years from the date of entry of the system into revenue service.

PART 2 – PRODUCTS

2.01 FUNCTIONAL REQUIREMENTS

A. Provide equipment, accessories, and incidentals necessary to implement a ETTS system for the new traction power facilities and designated existing TPFs. The ETTS shall be fully functional, as indicated on the Contract Drawings and as specified herein. Equipment shall include:

1. Emergency and Transfer Trip Cabinets (ETTCs) and Emergency Trip Panels (ETPs). In traction power facilities, provide ETTCs complete with logic controllers (LCs), input/output (I/O) modules, a DIOM in the case of a new or replacement TPF, fiber optic transducers, control power circuit breakers, inter-device wiring, fiber patch panels, fiber jumpers, and required ancillary equipment and accessories. In the DC switchgear and 64TC cabinets, provide IOMs and wiring accessories needed for interface with the DC circuit breakers, and Device 164 and Device 186 relays, respectively. In train control rooms, provide ETPs complete with I/O modules, fiber optic transceivers, terminal blocks, inter-device wiring, raceways to existing cabinets for the new wiring interfaces, control power circuit breakers, fiber patch panels, fiber optic cables to the FEC, and ancillary equipment and accessories to comprise complete and functional units.

2. TP Site BLSs. At each new TPSS provide a TP site BLS complete with an ETS with supervised circuit, and warning lights for DC switchgear frames alive/grounded status.

3. Interface Hard-Wiring. Provide hard-wiring and related appurtenances internal to ETTCs and ETPs, and wiring outside ETTCs and ETPs in the following areas:

    a. Between IOMs located in the DC switchgear and the 1000 VDC feeder breakers' protective relaying and controls. In the case of existing TPFs, the work shall include wiring modifications to the connection diagrams of the DC feeder circuit breakers, as needed to interface the ETTS with the breakers' protective relaying and controls, and to disengage the existing ET and TT systems.

    b. In new or replacement TP facilities, between an IOM for the ETTS in the 64TC cabinet and the Device 164 and 186 relays.

c. In new or replacement TP facilities, wiring of the trouble/alarm contacts of LCs, DIOMs and IOMs individually to the PLC in the C02 cabinet.

d. In existing TP facilities, wiring the trouble/alarm contacts of LCs and IOMs into a common circuit, to be connected to an existing SCADA circuit for remote alarm indication to the OCC.

e. In TCRs, wiring between the ETPs and the existing emergency wayside trip and platform trip circuits and devices.

f. In new or replacement TP facilities, wiring between the ETTC and the TP site BLS.

4. Fiber Optic Connections. FO based communications shall be provided between (a) LCs in different TP facilities in the same ETTS communications loop, (b) IOMs in the ETTC and IOMs in the DC switchgear and the 64TC cabinet in the same TP facility, and (c) DIOMs or IOMs in the ETTC, and IOMs in the TCRs, as indicated on the Contract Drawings. The FO communications between facilities shall be implemented by utilizing existing single mode FO cables laid by District. Regarding these cables the Contractor shall be responsible only for the interfaces, providing the jumpers, splice trays and other incidentals, and the overall design of the interface. FO links internal to the TP facilities and TCRs shall be by cables and accessories provided by the Contractor.

B. General ETTS Configuration. The ETTS shall be configured as a fiber-optic bi-directional loop-based system, where each loop includes the logic controllers (LCs) of two or more traction power facilities, as indicated on the Contract Drawings. A failure of any one fiber-optic segment of the loop shall not affect the proper operation of the ETTS.

C. Main Functionality. The LCs shall, through IOMs, trip open the required 1000 VDC feeder breakers in non-reclose or auto-reclose-enabled mode in accordance with the ETTS trip logic shown on the Contract Drawings. The non-reclose type trips shall de-energize the contact rails under emergency conditions, with the trip signals originating from platform trip stations, blue light stations, and DC switchgear ‘structure alive’ (Device 164) relays. Auto-reclose-enabled type trips are initiated by overcurrent or short-circuit fault detection, by the DC feeder circuit breakers’ protective relaying and the breaker’s instantaneous overcurrent release (Device 176). These types of trips shall allow attempts to reclose circuit breakers that have tripped on overcurrent detection.

D. Transfer Trip Test Switch. New DC feeder circuit breakers shall be equipped with transfer trip test switch located at the circuit breaker cubicle. The switch shall simulate an MPR transfer trip request for testing the logic and operation of the TT zone to which the breaker is connected. The LC shall be programmed to back-trip the circuit breaker from which the TT signal originates, to ensure proper transfer trip loop testing, as the TT test switch shall be wired to the ETTS only.

E. Interlock with the DC Feeder Breaker Position. Circuit breakers shall be tripped by the ETTS only when they are in the connected position. The ETTS shall not operate on circuit breakers that are in the test position.

F. Interface with the Device 164 Relay. Activation of the DC feeder circuit breakers 'structure alive' (Dev. 164) relay shall activate the ETTS, which shall then trip open all local and remote DC circuit breakers connecting contact rail sections supplied by the TP facility where the fault has been detected.

G. ETTS Alarms. The ETTS devices shall feature self-diagnostics capability and shall be equipped with form-c trouble/alarm contacts. The integrity of fiber optic (FO) communication and control circuits between network nodes shall be continuously monitored. In the event of FO circuit problem in an ETTS loop segment, a FO channel communication failure alarm shall be transmitted by the LCs in new TP facilities adjoining the faulted segment over Ethernet link to the control network switch in the C04 panel; and from there to the C02 panel's PLC for processing and for display on C02 alarm screen and to the OCC. For the same type of fault detection, LCs and DIOM located in existing TP facilities shall be programmed to provide a discrete output contact, which shall be hard-wired to an existing SCADA circuit with a remote alarm indication to the OCC. Additional alarms generated by the ETTS shall be as follows:

1. ETTS Self-Diagnostic Alarms in New TP Facilities: The alarm contacts of LCs shall be hard-wired individually to the PLC in the C02 panel for display on the panel's alarm screen, and shall be sent to the OCC.

2. ETTS Self-Diagnostic Alarms in Existing TP Facilities: The LC and IOM alarm contacts, along with the programmed output contact for communications channel failure of the LC, shall be paralleled and added to one existing SCADA alarm circuit for indication to the OCC. For TP facilities that had been equipped with an alarm station of the existing TT system, the existing 'Transfer Trip System Failure' alarm shall be used for this purpose. Otherwise, the alarm contacts of the ETTS devices shall be connected in parallel to the established alarm circuit of existing equipment, such as a summary 'TPF Equipment Trouble' alarm.

3. Hard-Wired Circuit Trouble Alarm for the TP Site BLS: This alarm, generated by the DIOM in the ETTC, shall be sent via hard-wiring to the C02 PLC and displayed on the C02 alarm screen. From the PLC it shall be sent also to the OCC. The equipment trouble alarm of the power supply shall be wired to the EXT-IOM and reported to C02 PLC.

4. Communication Channel Failure between a DIOM in a TPSS and IOM in a TCR: The DIOM shall detect a failure of the communications link to the paired IOM in the TCR and generate corresponding alarm through one of its discrete outputs. In a new TPSS this alarm output shall be wired to the C02 PLC for display on the alarm screen, and also sent to the OCC. In case of an existing TPSS, this alarm shall be paralleled with the other ETTS alarms and sent to the OCC using an existing SCADA alarm circuit.

5. Emergency Trip Alarms: Such alarms shall be transmitted from the LC receiving the initial trip signal, assuming the LC is located in a new TP facility, over Ethernet link to the C04 control network switch, from where they shall be routed to the C02 panel PLC for processing and for display on C02 alarm screen, and shall be also sent to the OCC. To the extent possible, these alarms shall distinguish the trip source by type and location.

    a. In case of a PTS-generated trip, the alarm shall identify the specific passenger station and platform.

    b. In case of a TP site BLS generated trip, the corresponding TP facility shall be identified.

    c. In case of a trip from a wayside ETS, if the ETS is on a dedicated circuit, its BLS shall be identified; if the ETS is in an existing circuit including more than one ETS, then the alarm shall identify the contact rail section from where the trip signal has originated.

    d. In case of a Device 164 initiated trip, the TPSS where the fault has occurred shall be identified.

6. Transfer Trip Alarms: If the LC receiving the initial TT signal is in a new TP facility, an Ethernet alarm for initiated TT by a specific circuit breaker shall be sent via the FO Ethernet link to the control network switch in the C04 panel; from where it shall be sent to C02 PLC for processing and for display on the C02 panel alarm screen, and to the OCC. If a LC is only receiving a TT alarm from another facility, an Ethernet alarm for such event shall be sent to the C02 alarm screen and to the OCC.

7. In a new TPSS, ETTS status and alarms generated by an LC other than the device-failure-related alarms shall be transmitted via Ethernet interface to the control network switch in the C04 panel. The LC's and IOM's trouble alarm contacts, and the DIOM-generated alarms, shall be hardwired individually to the PLC in the C02 panel for display on its alarms screen, and transmission to the OCC.

8. CR Gap Bypass Switches Status Indications: For TP substations equipped with contact rail (CR) gap bypass switches, the ETTS shall use inputs regarding the open/closed status of such switches to establish whether adjacent contact rail sections are linked electrically through the switch (which in turn affects the TT and ET logic). For this purpose, an auxiliary contact of the bypass switch operated at or near the switch's open position shall be used, indicating a 'Not Open' switch status as logical equivalent of 'Switch Closed' status for the ETTS. The status of these switches as recognized by the ETTS shall be sent over the Ethernet connection of the LC to the C04 control network switch. From the latter, these indications shall be routed to the C02 panel PLC for processing and for display on its ETTS alarm screen, and shall be sent to the OCC.

H. ETTS Loop Related Communications. LC backbone communications between TP facilities included in the ETTS communication loops shall be via existing single mode fiber optic cables passing through train control rooms, with the cables between the train control rooms, and between train control rooms and TP facilities, being provided by others. The Contractor shall be responsible for providing the terminations and interfaces for these cables at the TP facilities and in the TCRs. In the TCRs, where interconnections shall be made in existing BART FECs, the Contractor shall be responsible for designing the interface, and for furnishing hardware and accessories required for making the interface. The testing of the optic fibers used for the ETTS shall be the responsibility of the Contractor.

I. ETTS Communications inside Facilities. Fiber optic communications between pairs of IOMs located within traction power facilities, and between logic controllers and C04 network switches shall be via multimode fiber optic cables and shall be provided by the Contractor. Fiber optic communications between an ETTC in a TP facility and an ETP in a TCR shall be via single mode fiber optic cables, with the portion of the cables from the BART FEC in the TCR to the ETP provided by the Contract. FO cable terminations in new facilities and at new ETTS equipment in existing facilities shall be by the Contractor. Terminations to in-service BART equipment in existing District facilities will be done by District personnel.

J. Interface with the Maintenance and Engineering Network Switch in New Facilities. Permanent but removable remote access shall be provided to the LC via its USB port (normally used for local computer/ laptop connection) from the maintenance network switch located in the C04 cabinet. The connection shall be by using two conversion devices located in the ETTC: USB Serial to 100BASE-T copper Ethernet converter (Device Server) and copper-to-fiber media converter. The latter shall be connected to the maintenance network switch through fiber optic cable.

K. Operations with Interim ETTS Configurations with Partial Loops and No PTPSS. Such temporary ETTS configurations are used for staggered-in-time replacements of old TP substations, where the final ETTS loop includes more than one old TPSS and when a portable TPSS (PTPSS) is not used. Instead, during the substation's absence its sectionalizing gaps in the contact rail system are jumpered for electrical continuity of the contact rail. For the interim configurations of this type provide the following:

1. A partial ETTS loop shall be activated and put into service upon the return to service of the first new/replaced TPSS of the final loop.

2. In the operation of an interim configuration with a partial loop, ET based non-reclosing breaker trips within the normal limits of the loop in its final configuration shall be achieved by a combination of the operation of the partial ETTS loop and the existing ET system, with additional interfaces between the two implemented as required.

3. With regards to transfer tripping instigated by short-circuit fault detection that cause auto-reclosing-enabled circuit breaker trips, the operation of the interim configuration shall be in accordance with the following rules:

    a. If the fault is detected in a TP facility by a circuit breaker wired into the partial loop, the ETTS shall trip all other circuit breakers in the facilities participating in the partial loop, based on the TT logic as shown on the Contract Drawings.

    b. In the item 3 scenario above, circuit breakers in facilities not yet part of the ETTS but which also must be tripped in order to de-energize the required contact rail section will be the District's responsibility and will be tripped by the District's ICS/SCADA system.

    c. If the fault detection is only by a DC feeder breaker not yet part of the ETTS of the partial loop, it will be the responsibility of the District's ICS/SCADA system to trip all DC circuit breakers as needed to de-energize to faulted contact rail section.

4. Plan and complete the ETTS work in the existing TP facilities of the same loop so that field testing, SIT and commissioning of the partial loop can be done as soon as the first new/replaced TPSS of the final loop becomes available for service.

5. When a given ETTS loop reaches its final configuration remove from TP facilities and TCRs any equipment that had been installed, or required, only for the preceding interim loop configuration(s) and deliver equipment no longer needed to the District.

2.02 EMERGENCY AND TRANSFER TRIP EQUIPMENT

A. Logic controller, IOMs, and transceivers shall function properly operating in the following environmental conditions when tested per IEC 60068:

1. Cold: Equipment shall operate correctly at -40 degrees Celsius, for 16 hours when tested per IEC 60068-2-1.

2. Damp Heat, Steady State: Equipment shall operate correctly at 40 degrees Celsius and 93 percent relative humidity, for 4 days when tested per IEC 60068-2.

3. Damp Heat, Cyclical: Equipment shall operate correctly during 6 cycles of heat variation from 25 degrees Celsius to 55 degrees Celsius at 95 percent relative humidity when tested per IEC 60068-2-30.

4. Dry Heat: Equipment shall operate correctly at 85 degrees Celsius, for 16 hours when tested per IEC 60068-2-2.

B. Emergency and Transfer Trip Cabinet (ETTC) in New/Replacement TP Facilities: An ETTC shall be located in the DC switchgear house, as shown on the Contract Drawings. The ETTC shall include logic controllers (LCs), IOMs, a DIOM, fiber optic transceivers (FOTs), and accessories as indicated on the Contract Drawings and as specified herein.

1. The LC(s) shall be interfaced with the DC switchgear via one or more pairs of IOMs, where the IOMs in the ETTC are interconnected by multimode fiber optic links to a matching IOM located in the DC switchgear. The latter shall be hardwired both to the DC feeder circuit breaker MPRs, and to a second/backup emergency trip path to the DC feeder breakers' trip coils, as indicated in the Contract Drawings.

2. If a BLS trip request is received from the TP site BLS, the LC(s) shall trip the 34.5kV circuit breakers and all DC circuit breakers through direct trip by activating the Device 186 lockout relays and shall send non-reclosing trip signals to DC feeder circuit breakers in the local TP facility and in other TP facilities, as required to de-energize the contact rails at the affected TPSS.

3. The LC shall be interfaced with the Device 164 relay protecting the DC feeder breakers lineup. In the event of 'DC structure alive' detection by the Device 164 relay, the ETTS shall send trip signals to the DC feeder breakers in other TP facilities to result in de-energizing of the contact rails at the faulted TP facility.

4. LCs in adjacent TP facilities shall communicate over single-mode fiber optic links in a loop configuration using fiber optic transceivers (FOTs) connected to the serial ports of the logic controllers, as indicated on the Contract Drawings.

5. The DIOM(s) located in the ETTC, shall communicate via single-mode fiber optic cable with pair-matching IOMs in the adjacent TCRs, for interface with existing platform trip and wayside emergency trip circuits. The TCR IOMs and necessary ancillary equipment shall be housed in an emergency trip panel (ETP) located in the adjacent TCR.

6. The ETTC shall be wall mounted, single or double door, NEMA 4, constructed of at least 16-gauge steel, and shall be designed by the Contractor to house equipment indicated on the Contract Drawings at the specific site, with provisions for easy and convenient access for equipment maintenance. The ETTC enclosure shall be designed to meet the requirements of Article 1.08.D, entitled Equipment Construction, of Contract Specifications Section 34 21 01, General Requirements for the Traction Power System.

    a. The ETTC shall be equipped with:

        1) Wireways and terminal blocks for the I/O hard-wired interfaces, including a terminal block for grounding.

        2) Low-voltage circuit breaker for the 24 VDC power supply to the equipment.

        3) Internal grounding stud, for bonding the grounding terminals of the equipment to the frame of the enclosure.

4) External grounding stud, paint-free, at the bottom of the enclosure, for grounding the enclosure to the facility's ground system.

b. The ETTC shall be designed, including its installation and device mounting inside, to meet the requirements for essential equipment of Article 1.08.D.4, entitled Seismic Design Requirements, of Contract Specifications Section 34 21 01, General Requirements for the Traction Power System.

C. ETTC in Existing TP Facilities: At existing traction power facilities included in the ETTS loops, provide an ETTC of similar design and features for the new facilities, to house the equipment indicated on the Contract Drawings. The location of the ETTC shown on the Contract Drawings is approximate, and it may have to be adjusted following field investigation and assessment. Interface with existing dc switchgear shall be via pairs of IOMs in similar fashion as those in the new/replacement TP facilities.

1. Control power for the ETTC shall be obtained from the existing low-voltage DC distribution panel, supplied by the TPSS battery typically at 48 VDC.

2. The LC and IOM trouble/alarm contacts shall be wired in parallel to the existing SCADA alarm circuit for remote indication to the OCC. Provide a programmed discrete output from the LC to indicate loop communication channel failure. This output shall be wired in parallel with the device trouble alarm contacts for remote indication to the OCC.

3. Provide interposing relays for interface of the IOM(s) in the DC switchgear with the circuit breakers' trip coils for the emergency tripping functions.

4. Ancillary equipment such as raceways, terminal blocks, control wires for the circuit breakers' circuit modifications, inter-IOM fiber optic cable shall be provided as necessary for a complete functional interface.

D. Emergency Trip Panel (ETP) in train control rooms (TCRs): Provide ETPs in TCRs adjacent to TP facilities included in the ETTS loops, as indicated on the Contract Drawings. ETPs shall be wall mounted, single door, NEMA 4, constructed of at least 16-gauge steel, meeting the requirements of Article 1.08.D, entitled Equipment Construction, of Contract Specifications Section 34 21 01, General Requirements for the Traction Power System. The ETP shall be designed to house the following equipment and include the following features:

1. One IOM or more IOMs, as indicated on the Contract Drawings.

2. FOTs for the IOMs, as indicated on the Contract Drawings.

3. Low-voltage circuit breaker for the 125 VDC power supply to the IOM(s).

4. Terminal blocks and wire ways for the hard-wired circuits to the IOM(s).

5. Mini fiber patch panel for the fiber optic links of the IOM(s) to the BART FEC in the TCR, and fiber jumpers with ST connectors.

6. Equipment mounting hardware and accessories, as required.

7. The ETP enclosure shall feature internal grounding stud, for grounding the enclosure to a chassis ground available in Cabinet 23 of the TCR.

8. The ETP enclosure shall be designed to meet the requirements for seismic design (as essential equipment), equipment painting and static signs of Article 1.08.D, Equipment Construction, of Contract Specifications Section 34 21 01, General Requirements for the Traction Power System.

E. Blue Light Stations (BLS)

1. A BLS shall be provide near the main man-gate for a replacement outdoor TPSS or GBS, or at the main maintenance access doors of a new or replacement indoor TPSS or GBS. The BLS shall allow emergency response personnel and authorized personnel to de-energize the TPSS 34.5 kV and 1000 VDC systems and communicate with the BART Operations Control Center (OCC). BLSs shall be provided as specified herein and as indicated on the Contract Drawings.

2. Equipment Components: BLS shall consist of the following components, contained within a weatherproof enclosure:

   a. Enclosure: Construct enclosures from at least 1/8-inch-thick aluminum with an anodized finish. The two-compartment enclosure shall be NEMA type 3R rated. Left side door (for accessing ET and contact rail switch) shall include spring-loaded closure hinges and pull handle with magnetic latch.

   b. Emergency Telephone (ET) Set: Provide ET set as described in Contract Specifications Section 27 30 01, Telephone Systems, Article 2.02, entitled Emergency Telephone (ET) System.

   c. Emergency Trip Station (ETS): Provide an ETS in the BLS to trip the 1000 VDC traction power feeder breakers and 34.5 kV AC circuit breakers of the related TPSS. When activated the ETS via the ETTS shall de-energize the contact rails in the vicinity of the TP facility by tripping open the remote DC feeder circuit breakers connected to the same contact rail sections. The contact switch shall be a red mushroom head pushbutton type switch, with spring return.

      1) Equipment Components: The ETS housed in the BLS enclosure shall consist of a pushbutton with one normally-open contact, spring return type.

      2) Activation and Remote Indication: Depressing the pushbutton of the ETS shall close its contact, which in turn shall result in tripping of the appropriate 34.5 kV AC and 1000 VDC circuit breakers.

3) Connections: The BLS ETSs shall be hardwired to the DIOM in the facility's ETTC, as indicated on the Contract Drawings. The DIOM shall connect to the ETTC logic controller, which shall initiate circuit breaker tripping and alarm annunciation.

4) ETS circuit supervision: The ETS circuit between the BLS and the TPSS shall include a supervision module/DIOM in the ETTC. The DIOM shall monitor the integrity of the hard-wired circuit to the BLS by circulating milliamp current in it, with the circuit featuring an end-of-line resistor connected in parallel to the trip contact of the ETS pushbutton. In addition to ETS-generated trip signal conveyed to a LC in the ETTC, the DIOM shall indicate an open circuit wiring problem and generate corresponding alarm, that shall be sent to the C02 panel and OCC.

d. DC structure alive: Provide dc switchgear structure alive indication via warning lights at the BLS, as indicated on the Contract Drawings. Provide Light Test pushbutton as indicated on the Contract Drawings. Actuation of the pushbutton shall turn on the DC structure alive warning light verifying the light is operational. The pushbutton shall be weather-proof and made for use in outdoor environment for 120V ac applications.

e. Power: 120 VAC is required for light and 125 VDC for dc switchgear structure alive and grounded warning lights.

f. Emergency Trip Station Blue Light: Provide blue light fixtures that are Underwriters Laboratory listed for wet locations, and that include the following features, appurtenances, and accessories:

1) Provide housing and outlet box of glass reinforced polyester material conforming to UL 94V-0. Polyester housing and box shall be minimum 30 percent glass material, non-fading, permanent gray color, ultraviolet resistant. Nonmetallic fixture shall conform with UL 595.

2) Provide blue enclosing glove of heat-resistant glass with integral male threads for mounting into housing.

3) Provide one fixture with two lamps, each with individual ballast, or provide two one-lamp fixtures. Each lamp shall be 20 W to 25 W, 120 VAC. Lamp type shall be exterior column mounted, linear LED luminaire. Lamp lens shall be wrap around polycarbonate or high-impact acrylic diffuser, with even light distribution, secured to the housing with tamper resistant fasteners. Lamp housing shall comply with UL 8750. Lamp's correlated color temperature (CCT) shall be 4000 to 6000K. If used, LED driver shall be field replaceable. Lamp MTBF shall be 50,000 hours minimum.

4) Boxes shall be four-way tapped for 3/4-inch conduit. Plugs shall be of the same polyester material. Provide box with mounting ears.

F. ETTS Logic Controller (LC)

1. The logic controller for the ETTS shall be a discrete programmable automatic controller, SEL-2440 manufactured by Schweitzer Engineering Laboratories, or equal.

2. Logic controller shall be surface mounted inside the ETTC.

3. The standard I/O quantity option (32 inputs and 16 outputs) shall be used as the default choice. Options and accessories to the LC shall be such as to meet the requirements indicated on the Contact Drawings.

G. Input Output Module (IOM)

1. IOMs for the ETTS shall be SEL- 2505 Remote I/O Modules manufactured by Schweitzer Engineering Laboratories or equal.

2. IOMs shall be surface mounted inside ETTCs and ETPs, and at other locations as indicated on the Contract Drawings.

3. The IOMs used in pairs inside a TP facility shall be furnished with fiber-optic ready internal board for multimode FO communication. The board shall be with built-in transceivers such that there is no need for fiber attenuators for the serial communication between the IOMs of the pair, considering the short distances involved.

4. The IOMs in the TCRs, and those in ETTCs used to communicate with the ETP in a TCR, shall have an RS232 serial port to which an external fiber-optic transceiver shall be fitted that does not require fiber attenuator for single mode FO communication with the matching device at the other end.

5. The IOM power supply shall be selected depending on the IOM's location and available nearby power sources. If the Contract Drawings show a preferred power supply, it shall be used.

H. Fiber Optic Transceivers (FOT)

1. FOTs for inter-facility communications shall be a single mode transceiver, SEL-2829 manufactured by Schweitzer Engineering Laboratories or equal. The FOT shall be coordinated with the distance involved and pertinent ETTS transmission characteristics so that there is adequate reach and in the cases of shorter distances avoidance of optical signal reflections (so that there is no need for fiber attenuators). FOTs shall be compatible with other ETTS system components supporting fast data transfer using Mirrored Bits Protocol or equal.

I. IOM with Circuit Supervision Module Capability (referred to as diagnostic IOM, or DIOM): The DIOM shall be a programmable logic controller equipped with analog inputs and discrete I/Os.

1. The DIOM shall be located in the ETTC of TP Facility. The type of DIOM used in the ETTC shall be selected by the Contractor and shall be coordinated in advance with the District. The DIOM shall:

   a. Monitor the integrity of the hard-wired trip circuit between the ETTC and substation site BLS using circulating current through one of its analog inputs and recognize both a trip signal from the ETS and an open circuit wiring problem. A BLS trip shall transmit the corresponding trip command to the LC for further action. If a trip circuit wiring problem is detected then an alarm shall be generated, which shall be hard-wired individually to the LC for

Ethernet reporting to C02 PLC via C04 control network switch, for display on the C02 alarm screen and re-transmission to the OCC.

b. Communicate via its RS232 serial port and FOT with an IOM in the ETP in the adjacent TCR that receives emergency trip signals from the ETP and re-transmits them to the LC through a hard-wired interface.

c. Monitor the integrity of the communication with the ETP in the adjacent TCR. If a problem with communications link is detected, an alarm shall be generated and hardwired to the C02 PLC. The alarm shall be displayed on the alarm screen, and sent to the OCC.

2. The DIOM shall be the SEL-2411 Programmable Automation Controller manufactured by Schweitzer Engineering Laboratories or equal. DIOMs shall be compatible with other ETTS system components supporting fast data transfer using Mirrored Bits Protocol or equal. The specific configuration from the available options shall be selected by the Contractor to meet the I/O requirements at the specific location, as indicated on the Contract Drawings.

J. DC-to-DC Voltage Converter: The step-down voltage converter used in conjunction with the DIOM as power source for its analog inputs shall be a DC-to-DC converter for low-voltage devices, SEL-9321 manufactured by Schweitzer Engineering Laboratories or equal.

K. Fiber Optic Connectors

1. Provide LC connectors in all applications, unless such connectors are not acceptable by the device or its FO port.

2. If LC connectors are precluded, then provide ST connectors.

L. Hard Wiring in TPFs and TCRs

1. Provide stranded copper wires of size as indicated on the Contract Drawings, with #16 AWG serving as the minimum default size.

2. Wire Insulation: Rated 600-volt, flame retardant and non-propagating, passing the IEEE 383 and UL vertical tray flame test.

3. Wire Terminations: Ring-type crimp lugs.

M. Provide the following equipment for installation in old existing traction power facilities included in the ETTS, using 48 VDC control power:

1. Emergency Trip Relay

a. Emergency Trip Relay: Heavy duty DC power relay, Tyco PRD, or equal.

1) DPDT, auxiliary contacts with magnetic blowout

2) Contact Rating: Minimum 20 A continuous at 125 VDC

3) Coil Rating: Nominal 48 VDC

4) Pick Up Voltage: 75 percent or less of nominal

5) Operate Time: 30 milliseconds ± 5 milliseconds

6) Expected Life (Electrical): 100,000 operations at rated load.

7) Provide dust cover with each relay.

2. Disconnect Means

a. Disconnect terminal block: 300V, 30 A, 24-10 AWG, Euro T4 series or equal.

1) DIN rail and mounting hardware: Per manufacturer.

2) Disconnect type: Copper bar and 1A fuse.

3. 48 VDC Control Power Circuit Breaker

a. Contractor shall field verify requirements and procure circuit breaker suitable for the existing DC power supply panel, with following minimum characteristics:

1) Configuration: 1 phase, 2 pole, bolt-on connection.

2) DC Rating: 240 V, 15 A or 20 A.

3) Protection: Thermal magnetic, instantaneous, and long-time.

4. Enclosures: Designed to meet the requirements for seismic design (as essential equipment), equipment painting and static signs of Article 1.08.D, entitled Equipment Construction, of Contract Specifications Section 34 21 01, General Requirements for the Traction Power System. Furnish enclosures with the following characteristics:

a. 16-gauge steel, minimum; or made of fiberglass, if so indicated on the Contract Drawings.

b. Flush cover and offset body.

c. Removable doors with butt hinges, recessed T-handle latch flush with door.

d. Mounting holes on rear of enclosure; 4 mounting studs.

5. Mounting panels: Glastic, NEMA GPO-2, UTS 1478, thickness 3/8 inches, red color.

N. Additional equipment in ETTCs in new TP facilities, for connecting each LC via its USB port to the Maintenance Network Switch in the C04 cabinet used for enabling remote access to the LC from the Maintenance Network Switch:

1. USB Device Server: Digi - AnywhereUSB/2 or equal. USB device server shall include:

a. Two USB ports

b. One 10/100Base-T Ethernet port

2. Media Converter (copper-to-fiber): Unmanaged fast ethernet media converter.

   a. Incoming port shall be 10/100Base-TX (RJ-45 connector).

   b. Outgoing port shall be 100Base-FX; 1300 nm Multimode (ST connector). Supported link distance shall be 2 km per 1.2 miles minimum. Link budget shall be 11.0 dB minimum.

   c. Fault alarm reporting: Dry contact relay alarm output.

   d. Operating temperature: -40 to +75 degrees Celsius.

   e. Power input shall support redundant input power connections.

   f. External AC/DC Power Supply:

      1) Input voltage: 85 to 264 VAC, 120 to 370 VDC.

      2) Output voltage: 10.8 to 13.2 VDC, 2A.

      3) Power: 24 Watts

   g. Media converter shall be SISTF Series, by Transition Networks or equal.

2.03 SPARE PARTS

A. Furnish the following spare parts, rounded up if quantities are fractional:

1. One (1) logic controller per five (5) ETTCs.

2. One (1) IOM per ten (10) IOMs.

3. One (1) DIOM per five (5) ETTCs in new TP facilities.

4. Two (2) FO transducers per five (5) ETTCs.

5. One (1) BLS assembly per two (2) new TP substations.

6. Two (2) 48 VDC emergency trip relays per old TPSS included in the ETTS.

7. One (1) DC-to-DC voltage converter for each spare DIOM.

8. One (1) USB device server and one (1) media converter per five (5) ETTCs in new TP facilities.

2.04 EMERGENCY AND TRANSFER TRIP CONTROLLER SOFTWARE

A. General: Configure the software/firmware of the logic controllers and diagnostic IOMs to meet the functional requirements of the ETTS system as specified herein, and as indicated on the Contract Drawings. Information about existing ETTS system software, if needed by the Contractor to develop and implement software interfaces in the system programming will be provided by the District. Interfaces between new and existing ETTS software, if such are present, shall be developed, tested, and implemented by the Contractor.

B. ETTS Logic Controller (LC): The Contractor shall program the ETTS logic controllers in each new and existing TP facility as follows:

1. LC in a TP facility shall be programmed and configured for communication via its two serial ports with logic controllers in all other traction power facilities included in the same ETTS communication loop. The communication medium shall be pairs of single mode optic fibers, and the reach and configuration of each ETTS loop shall be as indicated on the Contract Drawings.

2. The Contractor shall program the LCs using fast data transfer Mirrored Bits Protocol or equal to send and receive platform, emergency, and transfer trip requests and commands from a given TP facility to all other TP facilities in the same communication loop.

3. An ETTS communication loop shall remain fully functional if one fiber path is lost between two adjacent LCs.

4. The LC software shall accept, process, and convey:

    a. Emergency trip, non-reclosing type requests received from IOMs connecting to platform trip and wayside emergency trip circuits in TCRs, from Device 164 relays protecting the DC feeder circuit breakers in the replacement TP facilities, and from the TP site BLS. Where possible, use odd numbered mirrored bits and I/O terminals of LCs and IOMs to accommodate the non-reclosing trip commands.

    b. Transfer trip requests permitting breaker auto-reclosing received from IOMs connected to DC feeder circuit breakers' protective relaying and instantaneous release (Dev. 176) devices. Where possible, use even numbered mirrored bits and I/O terminals of LCs and IOMs to accommodate auto-reclosing-enabled transfer trip commands.

5. The ETTS control logic shall be configured to meet the circuit breaker trip requirements and MPR and direct circuit breaker control scheme interfaces as indicated herein and on the Contract Drawings.

6. In the event of an emergency trip initiated by a PTS, the ETTS shall not allow energizing of the affected contact rail section at the platform until the activated PTS has been manually reset.

7. In the event of a transfer trip, the LC receiving the initial TT request shall also back-trip the originating circuit breaker, to ensure proper TT scheme operation in case the transfer trip signal has been generated by the circuit breaker's TT test switch.

8. Contact rail (CR) sectionalizing gaps at new or replacement TP facilities are equipped with normally open (NO) gap-bypass disconnect switches. As the closing of such a switch will connect two adjacent CR power sections, the ETTS shall monitor the status of these switches, and the LCs logic shall maintain correct operation of the emergency tripping and transfer tripping functions in the resulting new longer CR power section, if the bypass switch has been closed.

9. All standard logic controller hardware and application program error diagnostics shall be summarized and reported (via alarm contact of the LC) to the C02 Panel and the ICS (EBP included) as “LC TROUBLE”.

10. Logic controllers shall be programmed to monitor whether the fiber optic links to the adjacent LCs in the ETTS loop are operational by polling the associated hardware at the other end of the link. If the logic controller does not receive a confirming test input signal within two seconds, a “LC Channel ‘X’ Communication Trouble” alarm shall be generated, and in the case of a new TP facility transmitted over the Ethernet connection to the control network switch in the C04 panel, for re-routing to the C02 panel and the ICS. If the LC is located in an existing TP facility, this alarm shall be programmed to activate a discrete output contact, which shall be paralleled with the LC’s standard alarm contact and the resulting circuit connected to an existing SCADA alarm circuit for remote indication of ETTS equipment trouble at the OCC.

11. Logic controllers shall have software programming capability for communication of ETTS operational alarms over Ethernet connection to the control network switch located in the TP facility’s C04 cabinet, as indicated on the Contract Drawings.

C. Diagnostic I/O Module (DIOM): The Contractor shall configure and program the DIOM in each TP facility as follows:

1. In a new TP facility, the DIOM shall be programmed and configured for supervision of an analog trip circuit to the TP site BLS, including detection of trip signals from the ETS in the BLS, and circuit continuity problems. An in-series and end-of-line resistors shall be used for circuit calibration, as indicated on the Contract Drawings. The Contractor shall be responsible for determination of the values of the resistors and all circuit parameter settings.

2. The DIOM shall be programmed for communication via its serial port, FOT and single mode fiber cable with an IOM in the adjacent TCR, where the IOM provides hard-wired interfaces with existing platform trip and wayside emergency trip circuits. The communication with the TCR IOM shall be via fast data transfer Mirrored Bits Protocol or equal (the same software protocol used for communication between LCs connected in an ETTS loop). Received trip signals from the TCR IOM shall be transmitted via hard-wire interface to the LC(s) in the ETTC, as indicated on the Contract Drawings.

3. The DIOM shall be programmed to monitor via constant polling whether the fiber-optic communication link to the IOM in the TCR is operational and healthy. If a down time or off period in the communication channel exceeding two seconds is detected, the DIOM shall be programmed to raise an alarm through a discrete output contact. In the case of a new TP facility, this alarm contact shall be hard-wired to the C02 PLC, and from there sent to the OCC. In the case of an existing TP facility, this alarm contact of the DIOM shall be paralleled with its standard equipment trouble alarm contact, and the resulting circuit connected to an existing SCADA alarm circuit for a remote indication of ETTS equipment trouble at the OCC.

2.05 SPECIAL TOOLS

A. General: Furnish the following special tools for testing of the ETTS. Upon completion of the Work, the following special tools shall be delivered to District:

1. Minimum two (2) SEL-4388 Mirrored Bits Testers or equal.

2. LV test switches for simulating voltage-based input signals to the discrete inputs of LCs and IOMs in numbers required for the ETTS testing.

PART 3 – EXECUTION

3.01 GENERAL

A. The Contractor shall provide all equipment and materials and shall configure all application software to form a complete functioning system for all ETTS, as indicated on the Contract Drawings.

B. Installation and testing of the fiber optic and communications cables, communications grounding and the associated equipment described within this section shall be performed in compliance with implementation and test requirements of the TIA-455-C, TIA 455-13, TIA-526-7-A, TIA-526-14-C, TIA-568.0-D, TIA-568.1-D, TIA-568.2-C, TIA-568.3-D, TIA-569-D, TIA-606-B and TIA-607-C standards. Refer to Section 27 13 01, Communication Cables and Related Equipment for additional requirements for the communications cabling and equipment.

3.02 INSTALLATION

A. General

1. The Contractor shall:

a. Be responsible for executing integration of all new ETTS equipment with the existing emergency trip systems, with access points in the TCRs. Existing transfer trip systems shall be completely replaced by the new ETTS. To that end, in existing TPFs included in the ETTS loops the Contractor shall remove the existing TT system's interfaces with the DC switchgear and shall salvage the TT circuit boards.

b. Field verify that the record drawings used for developing the modifications to DC circuit breakers' controls in the existing TPFs, and interfaces with the existing ET systems in the TCRs, are correct.

c. Inspect and verify correctness of the terminations and connections of ETTS fiber optic and control cables in TPSSs, GBSs, and TCRs.

d. Develop and apply appropriate cable and wire designations, labeling and terminations complying with BART conventions.

e. Coordinate with Engineer to obtain necessary work orders for specific sites and safe clearances.

2. Existing traction power and train control facilities where new ETTS equipment is to be installed will be BART system's in-service facilities. Utmost care shall be taken to avoid interference with BART operations other than what has been precisely agreed to in advance in a Site Specific Work Plan (SSWP).

   a. Work involving wire terminations at, or wire removals from, existing equipment shall be performed only during non-revenue hours, as specified in Contracts Specification Section 01 11 00, Summary of Work.

   b. Work in compartments or raceways containing 1000 VDC buses or parts at high potential shall be done with the respective facility de-energized, that are either during the system non-revenue hours; or, during the off-peak hours. The off-peak hours are from 10:00 a.m. to 2:30 p.m. on weekdays, or on weekends.

3. The Contractor shall remove disconnected wiring and equipment to be demolished or salvaged, and shall install new equipment and wiring, as indicated on the Contract Drawings, and as necessary for a fully functional ETTS. Disconnecting existing wiring from, terminating new wiring to in-service equipment in existing facilities, and connecting fiber optic cable to existing FPPs and FECs of the BART system, will be done by BART personnel with support by the Contractor.

4. The Contractor shall follow requirements of Contract Specifications Section 34 21 70, Traction Power Facilities Installation Requirements, in all work at new or replacement facilities, or at existing adjacent BART facilities included in the ETTS network.

5. Raceways in Existing Facilities

   a. Use of Existing Raceways: Existing cable trays may be used for the new circuits where suitable, as indicated on the Contract Drawings; or per Contractor's request, subject to approval by the Engineer. Flexible conduit shall be installed on the existing cable trays for the new wiring.

   b. New Raceways: Conduit of the type indicated on the Contract Drawings, attached to walls, ceiling, or existing raceway infrastructure, shall be used for new raceways between different equipment and cabinets. The raceways shall be complete with the required supports and accessories.

c. New Conduit Inside Switchgear Cubicles: Install flexible conduit inside DC switchgear and relaying enclosures, from the point of entry of the new wiring to the vicinity of the new ETTS equipment.

d. Installation Design for ETTS Enclosures and Raceways: The Contractor shall be responsible for the installation design of all ETTS enclosures and new raceways, including final raceway routing selection, supports, bracing, and anchoring. For reference, see Article 1.08.D entitled Equipment Construction of Contract Specification Section 34 21 01, General Requirements for the Traction Power System. The design shall meet the seismic requirements of the Contract for essential equipment.

B. Installation in New/Replaced Traction Power Facilities

1. Install ETTS system components including ETTCs, IOMs, DIOMs, BLSs, conduit and other raceways, control wiring, wiring devices like terminal blocks, fiber optic connections, and all other ETTS ancillary equipment as required herein and as indicated on the Contract Drawings, as part of the TP facility's installation.

2. Use terminal blocks to interface LCs and IOMs with wire runs.

C. Installation in Existing Traction Power Facilities included in the New ETTS

1. Demolition and Salvaging: Remove existing wiring marked for demolition on the Contract Drawings. Existing transfer trip circuit boards in TPFs where the new ETTS is installed shall be salvaged after the removal of their wiring interfaces. Deliver the old transfer trip boards to BART storage as directed by the Engineer.

2. New Equipment Installation: Install new ETTS equipment including ETTCs, LCs, IOMs, aux relays for the emergency tripping, control wiring including wiring devices like terminal blocks, fiber optic cables, jumpers and connectors, conduits and accessories, 48 VDC circuit breakers and supply circuits, enclosures, and all required ancillary equipment to achieve a complete and functional new ETTS system, as specified herein and as indicated in the Contract Drawings. Install wiring internal to the ETTS enclosures, and external to the points of connection with the existing equipment. Installation requirement for existing facilities shall conform to those for new facilities.

3. Wiring Access to DC Switchgear Cubicles: Where possible and practical, for control wires use existing cable trays and wireways on top of the switchgear for wiring access to the target cubicles and compartments. Fiber-optic cables to the DC switchgear shall be installed separately, in a rigid conduit up to switchgear enclosures.

4. Height of Installation of ETTS Cabinets and Enclosures: Unless otherwise approved by the District, the top of the ETTS cabinet or enclosure shall be located 66 inches off the finished floor.

5. IOM and New Emergency Trip (Dev. 195) Relays Installation in the DC Switchgear: The Contractor shall determine locations of the IOM, Dev. 195 relays and related accessories inside the DC switchgear cubicles, and related installation details, based on field investigation of the subject TPF as needed to determine relevant design details and development of the installation design.

6. Auxiliary IOM Enclosure: If there is no space for the new ETTS equipment to be located in the DC switchgear existing relay compartments of the circuit breakers, the new ETTS devices shall be installed in a new auxiliary IOM enclosure located at the end of the DC switchgear lineup. The Contractor shall design the auxiliary enclosure and the means of access to the existing relaying and control wiring of the switchgear, based on field investigation of the particular TPF.

7. Wiring and Fiber Optic Terminations at Existing Circuits and Devices: Wiring and fiber optic cable terminations at existing circuits and devices, and modifications to existing circuits, will be performed by District personnel and shall be supported by the Contractor. The installation of the new wiring, and the clearing of old disconnected wiring, shall be the responsibility of the Contractor.

8. Work Hours Restrictions: The following time-of-day restrictions apply to the work in existing TP facilities, depending on the nature of the work:

    a. Installation of IOMs, auxiliary relays, and related accessories in the DC switchgear relaying cubicles, not involving wiring connections to existing circuits or modifications to existing circuits, shall be performed either during the non-revenue hours; or during off-peak revenue hours (which are between 10:00 a.m. and 2:30 p.m. on weekdays, and all day on weekends), if the TP facility is taken off-line (i.e. its DC circuit breakers are tripped open).

    b. Work that requires access to a cubicle with equipment at the 1000 VDC potential that is not protected by a physical barrier shall be performed with the subject equipment de-energized.

    c. Wiring modifications to existing DC circuit breakers' controls shall be performed only during non-revenue hours by BART personnel, with the Contractor in attendance in a support role. For definition of non-revenue hours, refer to Contract Specifications Section 01 11 00, Summary of Work.

D. Installation in Train Control Rooms

1. New Equipment Installation: Install the new ETTS equipment including ETP enclosures, IOMs, FOTs, fiber optic cables within the TCR to interface the ETP with the BART FEC Install mini fiber patch panels, fiber optic jumpers and connectors, conduits and attachment accessories, control wiring, 125 VDC circuit breakers, and all required appurtenances to achieve a complete and functional interface between the existing platform trip and wayside emergency trip systems and the new ETTS, as specified herein and as indicated in the Contract Drawings.

2. Demolition and Salvaging: New TPSSs operate initially in a configuration featuring temporary equipment for interface with the existing ET system, as indicated on the Contract Drawings. This temporary equipment shall remain until the inclusion of such TPSS in an ETTS communication loop. The ETTS operation in an interim configuration shall require some temporary wiring and equipment, as indicated on the Contract Drawings. The Contractor shall be responsible for the de-installation of such temporary equipment from the TCRs (as well as from the existing TP facilities, where applicable), removal of the associated wiring, and salvaging of the temporary ETTS devices and delivering them to the District.

3. New Raceways and Wiring: Provide all new raceways and wiring, necessary for interfacing the ETP with existing cabinets. Existing cable trays in the TCR may be used, where suitable, with flexible conduit installed on them for the new wiring circuits. Otherwise, use GRS conduit as a standalone raceway.

4. Existing Cabinets without Access for New Wiring: If an existing cabinet with which the ETP must be interfaced does not have access provisions for the ETTS wiring, the District will provide the means of entry (drilled new hole and conduit fitting).

5. Wiring Connections: Provide all wiring connections inside the ETP and install the new wiring from the ETP to the existing cabinets where the ETTS wiring interfaces are to be made. Coil 10-foot length of the new wires/cable on top of these cabinets. Connections of new wiring to existing circuits, or modifications to existing circuits, shall be made only by BART electricians during non-revenue hours, with the Contractor in attendance in supporting role.

6. Fiber-Optic Links between ETP and BART FEC: Provide mini FPP in the ETP, and two (2) single mode fiber optic jumpers with ST connectors for the IOM interface. Terminations at the ETP shall be by the Contractor. Terminations at the BART's TCR FEC shall be done by District personnel, per design by the Contractor and with materials and incidentals furnished by the Contractor. Provide the new fiber cables between ETP and FEC with circuit ID labels at both ends.

E. Hard Wiring in TPFs and TCRs: Use stranded copper wires of size as indicated on the Contract Drawings, with #16 AWG serving as the minimum default size.

1. Wire Insulation: Rated 600-volt, fame retardant and non-propagating, passing the IEEE 383 and UL vertical tray flame test.

2. Control Cable: Individual conductors run between different equipment cabinets and enclosures, if of the same wire size and routing, shall be cabled together in accordance with ICEA S-73-532 in a control cable with binder tape and flame-retardant jacket. Individual conductors shall be color-coded with base colors, and trace colors if needed, in accordance with ICEA S-73-532.

3. Tagging: Provide wire and conduit identification tags and labels conforming to Contract Specifications Section 26 05 24, Low Voltage Wires and Cables.

4. Grounding: For LC, IOM and enclosure connections to ground use insulated, green-colored #10 AWG conductor; refer to Section 26 05 26. Grounding and Bonding for Electrical Systems.

F. Inter-Facility Fiber Optic Cables

1. Inter-facility fiber optic cables (TPF to TCR, and TCR to TCR) are furnished and installed by District. They are single mode type. The Contractor shall design the interfaces at the new TP facilities, terminate the cables and assign the fiber strands for use by the ETTS.

2. To construct the ETTS communication loops, in the line segments between different facilities (TPFs and TCRs) the Contractor shall utilize spare fibers of the existing fiber-optic cables.

3. Fiber-optic cable terminations at existing BART FECs in the TCRs shall be made by District personnel per design by the Contractor, with materials (e.g. jumpers, connectors, support trays) furnished by the Contractor.

G. Sequencing of ETTS Installation in TCRs and Existing TPFs

1. Contractor shall complete the installation work, except for terminating circuits at interfaces with in-service equipment, in the TCRs and existing TPFs associated with a given ETTS communication loop before the finish of the installation of the first new or replaced TPF of the loop. This is necessary to ensure timely field testing and commissioning of the ETTS on a loop-by-loop basis, with no delays, either in an initial partial loop configuration or in a final loop configuration, depending on the case.

2. The order of multiple TPF replacements is provided in Contract Specifications Section 01 11 00, Summary of Work. Information about which TPF belongs to which ETTS communication loop, which is needed in order to plan the schedule of work in the TCRs and existing TPFs, is indicated in the Contract Drawings.

3.03 FACTORY ACCEPTANCE TESTS

A. Factory acceptance testing (FAT) per this Section shall cover the testing of each ETTS loop's logic controllers and DIOMs programmed and interconnected as they will be in the BART operating system. The test configuration shall include the LCs' connection to the facilities' C02 PLCs, using either the actual PLCs or emulating the latter by laptop computers, to confirm the proper operation of the Ethernet alarms, and the 'equipment trouble' alarms hardwired direct to the PLC.

1. Adjacent ETTS loops sharing control of a TP facility that has contact rail sectionalizing gaps with gap-bypass switches shall be part of the same physical test setup, which shall include the hard wiring between the LCs of the two loops in the common TPF. These tests shall be used to verify the proper functioning of all logic controllers in the test setup and confirm that their operation is in accordance with the required circuit breaker tripping logic under all simulated field conditions.

2. An exception to the above requirement concerning a TPF with contact rail gap bypass switches is allowed if one of the ETTS loops is part of another contract, or part of the existing BART system. In such case, the hard-wired interface between the two LCs in the substation with gap-bypass switches shall be simulated (based on the ETTS design).

B. Tests of system connectivity, performance, and response time shall be carried out on the factory floor with all ETTS logic controllers and DIOMs of a given test setup, as described herein, configured to match the actual field installation.

1. The Contractor shall develop a detailed test procedure for the FAT, including ETTS I/O schedule and testing sequence covering all possible ET and TT sources and ETTS configurations associated with a given ETTS loop. The results from the FAT shall be recorded on prepared in advance and approved test data sheets, that clearly define the system configuration, source and type of trip, how exactly the trip signal is applied or simulated, and the expected outcomes from each test. The test data sheets shall include the specific pass/fail criteria for each test.

2. Substitute short cable links for long fiber optic cables used in the field. Either the actual C02 PLCs or substitute laptop computers shall be used to verify the proper functioning of the Ethernet alarms of the LCs.

3. IOMs for interfaces with the DC switchgear and cabinet 64TC do not have to be part of this test. Instead, the status of hard-wired inputs and outputs of these IOMs in the ETTC may be monitored or simulated at the corresponding inputs and outputs of the respective LC. Test switches shall be used to apply voltage to the LC’s inputs, to simulate inputs from remote equipment.

4. The IOMs in the TCRs, shall be included in the FAT, with their fiber-optic connection to the corresponding DIOM or IOM in the ETTC represented by a short fiber optic link in the test setup.

5. Include the analog circuits of the DIOMs to the TP site BLSs as part of the FAT setup. Model the respective trip circuit to the BLS with its two resistors and circulating current. The proper operation of the supervised BLS circuit shall be confirmed by the FAT in both ‘emergency trip’ and ‘circuit trouble’ alarm mode.

6. The status of discrete inputs and outputs of the LCs shall be verified by observing their status LEDs, or by external indicators, as appropriate.

C. The FAT shall verify the circuit breakers tripping logic for emergency tripping and transfer tripping in accordance with the circuit breaker tripping logic tables indicated in the Contact Drawings. The tests shall include confirmation of the following requirements:

1. In the event of a trip signal originating from a PTS, attempts at closing the circuit breakers supplying the same de-energized contact rail section shall be blocked until the PTS pushbutton has been reset.

2. In the event of a transfer trip, the circuit breaker originating the transfer trip shall be back-tripped by the ETTS, to ensure proper TT operation if the breaker's TT test switch is used.

3. If there is a contact rail gap-bypass switch, either at a TPF inside an ETTS loop or at a TPF bordering two loops, the test shall include scenarios with the switch both open and closed, the latter case resulting in a configuration where two adjacent contact rail sections are bridged electrically. Transfer tripping and emergency tripping shall operate correctly for either position of the switch.

4. In the preceding scenario (per Article 3.03.C.3 of this Section) if one of the ETTS loops is absent due to conditions described in Article 3.03.A.2 of this Section, the proper operation of the tested loop under condition of closed gap-bypass switches shall be confirmed by simulation of the hard-wired interfaces between the logic controllers of the different loops in the TPSS with contact rail gap-bypass switches.

    a. ET and TT inputs from the absent LC shall be modeled by applying activating voltage at the required inputs of the present LC. With closed position of the gap bypass switch, the correct operation of the LCs of the tested loop shall be confirmed.

    b. With gap bypass switch closed for the present interface LC, the different ET and TT actions of the tested loop shall activate the correct outputs of the present interface LC (per ETTS design), which in the field condition will be wired as inputs to the absent interface LC.

5. ET and TT functions shall operate correctly with any one of the fiber-optic links between two adjacent nodes of the ETTS loop disconnected. The LCs at both ends of the disconnected fiber optic cable shall generate the appropriate 'Communication Channel Failure' alarm.

6. The FAT shall be used to confirm that upon removal of any emergency trip or transfer trip input signal to a LC, the ETTS communication loop status automatically resets to normal.

D. The FAT shall include verification of the proper functioning of all ETTS generated alarms, to be sent by the LCs over Ethernet links to the C02 PLC via the C04 control network switch in the case of a new TP facility, as shown on the Contract Drawings and required by the Contract Specifications. For LCs and DIOMs to be installed in existing TP facilities, the test shall confirm the proper operation of the programmed output contacts for the communication channel failure alarms.

E. For one LC, the FAT shall confirm the proper operation of the remote access to the LC via its USB port, using the communication conversion devices per this specification and as indicated on the Contract Drawings.

F. Following successful completion of the FAT, the Contractor shall use the same LCs, by model number and as already programmed, for installation in the same locations in the ETTS configuration in the field.

G. For replacement TP facilities with prefabricated switchgear houses, after successful completion of the FAT per this Section, the Contractor shall perform the ETTS-related factory tests per Contract Specification Section 34 21 75, Traction Power Facility Functional Factory Testing.

3.04 FIELD TESTING

A. General: Field testing of the ETTS shall be performed in stages as specified herein, with approved test procedures and test data forms, in accordance with Contract Specifications Section 01 45 24, Testing Program Requirements.

B. Stage 1 Field Testing for New or Replaced TPFs. These tests shall be performed upon completion of the TPF installation including ETTS wiring inside the TPF. The DC feeders will not yet be connected to the contact rails, but the 125 VDC, 24 VDC and LV AC systems shall be fully functional. The tests shall involve testing the ETTS equipment and wiring inside the TPF, the TP site BLS, and the ETTS equipment in the associated train control room (TCR). In the TCR, the ETTS devices shall be installed, with fiber-optic link to the TPF functional, wiring inside the ETP complete, and hard wiring from the ETP to existing cabinets installed and tagged but without the terminations to the existing equipment.

1. Actuate, one at a time, IOM inputs in the TCR simulating actual platform trip and emergency trip signals. Verify correct response by the circuit breakers of the TP facility to each signal. Using a mirrored bits tester on the LC's serial ports, verify that the correct (per design) mirrored bits are sent by the logic controller(s) for tripping the DC feeder breakers in other TPFs as required to de-energize the target contact rail section(s).

    a. In case of interim or final configuration where the ETP IOM has outputs wired to the existing ET system, the proper operations of these outputs in response to trip signals from the TPF shall be tested.

2. Actuate the ETS of the TP site BLS and confirm that the ETTS trips all circuit breakers of the TP facility. Using a mirrored bits tester confirm that the correct mirrored bits (per ETTS design) are sent through the serial ports of the LC for tripping remote DC circuit breakers in other TPFs, as required to de-energize the contact rails at the tested facility.

    a. In case of interim or final configuration where the ETP IOM has outputs wired to the existing ET system, confirm the proper operation of these outputs in response to the TP site BLS activation in the associated TPSS.

3. Actuate, one at a time, Device 164 relays in ‘structure alive’ and ‘structure grounded’ mode. Confirm via mirrored bits tester that in the case of ‘structure alive’ indication from the 164 relay protecting the DC feeder circuit breakers, the ETTS logic controller sends the correct mirrored bits to trip without reclose the remote DC feeder breakers that will result in de-energizing the contact rail sections at the tested TPF. Confirm that for all ‘structure alive’ and ‘structure grounded’ simulated faults from Device 164 relays, the corresponding warning lights at the TP site BLS function correctly.

    a. In case of interim or final configuration where the ETP IOM has outputs wired to the existing ET system, confirm the proper operation of these outputs in response to the Device 164 relay activation in the associated TPSS.

4. From the DC switchgear, generate one at a time, transfer trip signals by actuating the transfer trip test switch at each DC feeder breaker. Verify correct operation of the transfer trip circuits and logic by confirming correct response of circuit breakers to each TT signal, and that the DC circuit breakers tripped reclose. Using a mirrored bits tester at the ETTS logic controller, verify that correct mirrored bits for transfer trip signals are sent to the remote DC circuit breakers in other TP facilities supplying the same contact rail section as the one to which the tested circuit breaker is connected.

5. Using mirrored bits testers connected to the serial ports of the ETTS logic controller, generate one at a time, all mirrored bit inputs representing emergency trip and transfer trip signals received by the tested logic controller from other TP facilities based on the overall ETTS design. Verify correct operation of the transfer trip and emergency trip circuits and logic by confirming correct response of the DC circuit breakers to each signal. Confirm that:

    a. The correct DC circuit breaker is tripped;

    b. DC circuit breakers tripped in reclose mode reclose;

    c. DC circuit breakers tripped in non-reclose mode (i.e. emergency trip) stay open;

    d. In the event of a sustained input trip signal to the logic controller from a platform trip station, the target DC circuit breaker cannot be closed; and

    e. In case of interim or final configuration where the ETP IOM has outputs to the existing ET systems, confirm the proper operation of these outputs in response to received ET signals by the ETTC LC from other facilities.

6. Create ETTS device failure and circuit trouble conditions to verify that the fault is detected, and the correct alarm is generated. This failure mode testing shall include:

    a. Disconnecting the hard-wired trip circuit to the TP site BLS;

    b. Disconnecting, one at a time, the fiber-optic links between pairs of IOMs;

    c. Disconnecting the fiber-optic cable between the DIOM in the ETTC and the ETP in the TCR;

d. Removing the power supply of IOMs located outside of the ETTC; and

e. Removing the power supply to the ETTC.

7. For all tests in scenarios described above, verify that accurate alarm signals are received locally at the alarm screen of the C02 PLC.

C. Stage 1 Field Testing for Existing Old TPFs. These tests shall be performed upon completion of the installation of the new ETTS equipment in the TPF, except for the connections of the new wiring to the existing DC switchgear controls and indications, and the related modifications to the existing switchgear wiring. In case of a TPSS with associated ETP in a nearby TCR, the tests shall include the ETP. Wiring inside the ETP and the fiber-optic link to the TPF shall be completed, with hard wiring from the ETP to the existing cabinets installed and tagged but without the terminations to the existing equipment.

1. If the TPSS is connected to an ETP in a TCR, actuate, one at a time, all IOM inputs in the TCR simulating actual platform trip and emergency trip signals. Verify correct response at the outputs of the IOM in the DC switchgear, based on the ETTS design. Using a mirrored bits tester, verify that correct mirrored bits are sent by the ETTS logic controller via its serial ports for tripping the DC feeder breakers in other TPFs supplying the contact rail section(s) that must be de-energized.

2. From the DC switchgear, generate one at a time, transfer trip signals by actuating the required IOM Inputs. Verify by using a mirrored bits tester at the ETTS logic controller, that correct mirrored bits for transfer trip signals are sent to the remote DC circuit breakers in other TP facilities supplying the same contact rail section as the tested circuit breaker.

3. Using a mirrored bits tester connected to the serial ports of the ETTS logic controller, generate one at a time, all mirrored bit inputs representing emergency trip and transfer trip signals received by the tested logic controller from other TP facilities based on the overall ETTS design. Verify correct operation of the transfer trip and emergency trip circuits and logic by confirming the correct IOM Output in the DC switchgear is activated.

D. Stage 2 Field Testing, General Requirements. These tests shall be carried out for each ETTS communication loop, for each of its operational configurations: interim (if applicable) and final. They shall be performed after successful completion of the Stage 1 field tests for all TP facilities involved in the loop configuration. If a new TPF is common to two loops, the test setup shall include the facilities of both loops. Apart from confirmation of the ETTS breaker trip logic and correct wiring, and correct generation of ETTS alarms, these tests shall be used to confirm that upon removal of the trip-initiating signal the ETTS communication loop resets properly to its default status. Special requirements for these field tests are:

1. If an ETTS loop includes a TPF with contact rail sectionalizing gaps equipped with gap-pass switches, the stage 2 field tests shall be carried out with these switches both open and closed, to confirm the correct operation of the ETTS for both scenarios.

2. The stage 2 tests shall be repeated with one fiber-optic communication link between adjacent LCs of the same ETTS loop removed.

3. If some of the TP facilities, or parts thereof, included in the ETTS loop under test have already undergone similar field testing and SIT as part of a previous interim configuration, the operation of such already proven equipment and interfaces is not a target of the current field test, and does not have to be proved again. Such equipment shall be included in the loop for the sake of completeness and integrity of the network.

E. Stage 2 Field Testing, Specific Tests. The stage 2 field tests shall include the following:

1. Actuate, one at a time, all IOM inputs in each TCR of the test setup to simulate platform trip and emergency trip signals. Verify the response by the circuit breakers by circuit breaker ID and type of tripping in all TP facilities needed to de-energize the target contact rail section. In case of interim or final configuration where the ETP IOM has outputs wired to the existing ET system, test the proper operation of these outputs in response to trip signals from the TPF. For the platform trips, confirm that with the platform trip signal still present (PTS not yet reset) the DC feeder circuit breakers supplying the de-energized contact rail section cannot be closed.

2. At each replacement TPF in the test setup, actuate the ETS of the TP site BLS. Confirm that ETS actuation trips all circuit breakers of the associated TPF in non-reclose mode, and likewise trips all remote DC circuit breakers in other TPFs, as required to de-energize the contact rails at the tested facility.

3. At each replacement TPF in the test setup, actuate, one at a time, all Device 164 relays in ‘structure alive’ and ‘structure grounded’ mode. Confirm that in the case of ‘structure alive’ signal from the 164 relay protecting the DC feeder circuit breakers, the remote DC feeder breakers in other TPFs required to de-energize the contact rail sections at the tested TPF are tripped in non-reclose mode. In addition, confirm that for all ‘structure alive’ and ‘structure grounded’ simulated faults from all Device 164 relays, the corresponding warning lights at the TP site BLS function correctly. In the case of a new existing TPSS provided by others and operating with a temporary ET system interface, as the Device 164 relays are already wired into the temporary ET system and the TPSS is in service, simulate such inputs to the LC and the final system’s DIOM based on the ETTS design, in order to verify the response of the remaining LCs and DIOMs in the tested loop to such inputs.

4. Generate, one at a time, transfer trip signals from each DC feeder circuit breaker included in the tested loop. In replacement TPFs, do this by using the TT test switches of the circuit breakers. In existing TPFs with the circuit breakers’ wiring not yet modified, simulate the TT signal by activating appropriate inputs of the IOM located in the DC switchgear. Verify correct operation of the transfer trip circuits and logic by confirming correct response of the circuit breakers in the replacement TPFs included in the TT zone (per the breaker trip logic tables), as well as successful reclosing of the tripped circuit breakers. In existing old TPFs not yet wired into the ETTS loop, confirm that the appropriate output of the IOM

in the DC switchgear for transfer-trip of the required circuit breaker has been activated. If an existing TPF is already in service with the new ETTS wiring fully connected, use the same approach to confirm the correct TT responses, as in the replacement TPFs.

5. The correct response and operation of the listed below 'equipment trouble' alarms for each ETTS device and facility shall be confirmed by the following field tests:

   a. Disconnecting the hard-wired trip circuit to the TP site BLS;

   b. Disconnecting, one at a time, the fiber-optic links between pairs of IOMs;

   c. Disconnecting the fiber-optic cable between the DIOM in the ETTC and the ETP in the nearby TCR;

   d. Removing the power supply of IOMs located outside of the ETTC;

   e. Removing the power supply to the ETTC; and

   f. In case of a TPSS with CR gap bypass disconnect switches, confirming the proper operation of the switches' auxiliary contacts used for indication to the ETTS of the disconnect switches' open and closed positions.

6. For all tests per scenarios described above, verify that accurate alarm signals are generated by the LCs and are received at the alarm screen of the C02 PLC, and at the workstation or laptop computer connected to the control network switch in the C04 panel, emulating the interfaces with the integrated computer system (ICS) and emergency back-up panels (EBP1, EBP2).

7. At each new TPSS, where such a test has not been carried out, perform a test to prove that remote access from the maintenance network switch to each LC via its USB port is available and functioning properly.

3.05 SYSTEM INTEGRATION TESTING (SIT) AND COMMISSIONING

A. General: SIT for the ETTS shall be performed in accordance with Contract Specifications Section 01 45 24, Testing Program Requirements, and the SIT-related requirements of Contract Specifications Section 34 21 80, Traction Power System Field Acceptance Testing.

B. Sequencing of the Commissioning of Individual ETTS Loops: The ETTS communication loops may comprise a combination of replaced, and existing old or new TP facilities. If the final ETTS loop contains more than one replaced TP facility, the field testing, SIT and commissioning of the loop shall be carried out in stages involving interim configurations with partial loops. The interim configurations are outlined in Article 2.01 Functional Requirements under Part 2 herein and as detailed on the Contract Drawings.

END OF SECTION 34 21 35

SECTION 34 21 40

DC CONTROL POWER SYSTEM

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. General

B. Batteries

C. Battery Chargers

D. DC/DC Converters

E. Battery Racks and Ventilation System

F. DC Distribution Panelboards

G. Molded Case Circuit Breakers

H. Finishes

I. Local and Remote Alarm Annunciation

J. Emergency Eyewash

K. Spill Containment System

L. Accessories

M. Factory Installation

N. Factory Acceptance

O. Wiring, Terminations and Conduit Work

P. Grounding

Q. Field Installation

R. Field Touch-Up

S. Installation Verification, Field Functional and System Integration Testing

T. Cleaning

U. Demonstration and Training

V. Closeout Procedures

1.02 RELATED SECTIONS

A. Refer to the following Sections for requirements:

1. Section 01 45 24 Testing Program Requirements
2. Section 01 33 00 Submittal Procedures
3. Section 01 33 23 Shop Drawings, Product Data, and Samples
4. Section 01 43 00 Quality Assurance
5. Section 01 45 00 Quality Control
6. Section 01 74 14 Cleaning
7. Section 01 77 00 Closeout Procedures
8. Section 01 78 23 Operation and Maintenance Data
9. Section 01 78 39 Project Record Documents
10. Section 01 78 44 Spare Parts and Maintenance Manuals
11. Section 01 79 00 Demonstration and Training
12. Section 20 50 13 Raceways for Facility Services
13. Section 26 05 24 Low Voltage Wires and Cables
14. Section 26 24 24 Circuit Breakers and Panel Boards
15. Section 34 21 01 General Requirements for the Traction Power System
16. Section 34 21 05 Prefabricated AC and DC Equipment Houses and Related Equipment
17. Section 34 21 07 Prefabricated Portable Substations
18. Section 34 21 50 Common Materials and Methods for Traction Power
19. Section 34 21 60 Grounding and Bonding for Traction Power
20. Section 34 21 70 Traction Power Facilities Installation Requirements
21. Section 34 21 75 Traction Power Facility System Factory Functional Testing
22. Section 34 21 80 Traction Power System Field Acceptance Testing

1.03 MEASUREMENT AND PAYMENT

A. Separate measurement and payment will not be made for work required under this Section. All costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work.

1.04 REFERENCES

A. Activities shall be in accordance with the following codes, standards, and specifications except as provided otherwise herein. Where requirements conflict with requirements specified herein or elsewhere in the Contract the more restrictive requirements shall apply.

B. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE 450 IEEE Recommended Practice for Maintenance, Testing, and Replacement of Ventilated Lead-Acid Batteries for Stationary Applications

2. IEEE 484 IEEE Recommended practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications

3. IEEE 485 IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications

C. International Safety Equipment Association (ISEA):

1. ISEA/ ANSI Z358.1 American National Standard for Emergency Eye Wash and Shower Equipment

D. National Electrical Manufacturers Association (NEMA):

1. NEMA AB1 Molded Case Circuit Breakers, Molded Case Switches, and Circuit Breaker Enclosures

2. NEMA 250 Enclosure for Electrical Equipment (1,000 Volts Maximum)

3. NEMA PB 1 Panelboards

4. NEMA PE 5 Utility Type Battery Chargers

E. National Fire Protection Association (NFPA):

1. NFPA 70 National Electrical Code

F. Underwriters' Laboratories, Inc (UL):

1. UL 67 Standard for Safety Panelboards

1.05 SUBMITTALS

A. Refer to the following Sections for additional requirements:

1. Section 01 33 00 Submittal Procedures
2. Section 01 33 23 Shop Drawings, Product Data, and Samples
3. Section 01 78 23 Operation and Maintenance Data
4. Section 01 79 00 Demonstration and Training
5. Section 34 21 01 General Requirements for the Traction Power System
6. Section 34 21 75 Traction Power Facility System Factory Functional Testing
7. Section 34 21 80 Traction Power System Field Acceptance Testing

B. Submit the following documents for equipment and materials specified herein and provided under the Contract for the DC control power system:

1. Shop Drawings, including but not limited to, the following:
    a. Materials and method of construction.
    b. Physical arrangement drawings (including dimensions), and weight of equipment and major components.
    c. Complete unit wiring diagrams.
    d. Mounting locations and supports for equipment mounted in the cabinets and enclosures.
    e. Shop Drawings showing space available for conduit entrance, knockout locations, and for routing and training of cables. Available space shall take into consideration bending radius requirements of cables.
    f. Interconnection diagrams for circuits having externally located instruments, controls, alarms, and similar devices.
2. Product data: Submit product data for the battery, battery chargers, 125 V DC/24 V DC converter, 125 V DC/125 V DC converter, DC distribution panels, circuit breakers, battery rack, spill containment system, special installation tools, and accessories. Product data shall include product description, bill of materials, and detailed technical specifications.
3. Seismic calculations for the battery charger and battery rack assembly approved by California registered structural engineer.

4. Electrical design calculations for sizing the equipment based upon the electrical load at each traction power facility including:

    a. Power consumption calculations: Estimated average power/current and peak power/current demand shall be provided for the 125 V DC and 24 V DC (if applicable) control power systems.

    b. Battery, Battery Charger, and DC/DC Converter Sizing Calculations: Battery, converter and charger sizing shall be in accordance with the applicable IEEE Standards, and shall meet the requirements of this Section.

    c. Number of battery cells, number of strings, nominal voltage, amp-hours of each cell, electrolyte information, battery unit short-circuit currents.

5. Certificates from manufacturers verifying that equipment conforms to specified requirements.

6. Material safety data sheets.

7. Factory acceptance test documentation (e.g. test plan and procedures, data sheets, reports) per Section 01 45 24, Testing Program Requirements.

8. Final accepted DC control power system field acceptance test records, used as baseline equipment verification of condition.

9. Installation Manual and Drawings

    a. Installation manual shall include, but not limited to the following:

        1) A table of contents that shall identify pages of the manual by revision and date.

        2) The installation practices and procedures that the Contractor plans to use to accomplish the installation of the DC control power system and associated materials detailed in this Section. Documentation shall be kept current.

        3) A list of installation drawings by number, revision, title and approval status and a copy of each drawing reduced to B size (11 by 17 inches).

        4) Quality control procedures associated with the transportation and installation of the DC control power system and associated materials.

        5) Installation verification procedures and data sheets.

        6) Staging and implementation plans.

        7) Recommended maintenance equipment cycles and procedures.

10. Installation verification and field functional test documentation (e.g. procedures, data sheets, reports) per Section 34 21 80, Traction Power System Field Acceptance Testing.

11. System integration test documentation (e.g. procedures, data sheets, reports) per Section 34 21 80, Traction Power System Field Acceptance Testing.

12. Spare Parts List: Refer to Section 01 78 44, Spare Parts and Maintenance Materials for requirements.

13. O&M Manuals (Systems): Refer to Section 01 78 23, Operation and Maintenance Data for requirements.

14. Training Materials: Refer to Section 01 79 00, Demonstration and Training for requirements.

15. Warranty Certification.

1.06 QUALITY CONTROL, QUALITY ASSURANCE, AND SUPPLIER QUALIFICATIONS

A. Refer to Section 34 21 01, General Requirements for the Traction Power System; and Section 34 21 70, Traction Power Facilities Installation Requirements, for requirements.

B. The system and components shall conform to IEEE 485, NEMA 250, NEMA AB1, NEMA PB1 and UL 67.

1.07 DELIVERY, STORAGE AND HANDLING

A. Refer to Section 34 21 70, Traction Power Facilities Installation Requirements, for requirements.

B. Refer to Section 34 21 07, Pre-Fabricated Portable Substations, for additional requirements for portable substations.

C. Equipment shall be handled and stored in conformance with manufacturer's instructions. One copy of these instructions shall be included with the equipment at time of shipment.

1.08 GENERAL REQUIREMENTS

A. Refer to Section 34 21 01, General Requirements for the Traction Power System, for requirements.

1.09 SPARE PARTS

A. The following spare parts shall be supplied.

1. 1 – Battery Charger Rectifier Circuit

2. 1 – Battery Charger Isolation Transformer

3. 1 – Battery Charger Ripple Monitoring Circuit printed circuit board

4. 1 – Battery Charger Control Circuit printed circuit board

5. 1 – Battery Charger Regulator Circuit printed circuit board
6. 1 – Battery Charger Fault Detection printed circuit board
7. 1 – DC/DC Converter
8. 1 – DC Circuit Breaker 50A
9. 1 – DC Circuit Breaker 30A
10. 1 – DC Circuit Breaker 20A

1.10 WARRANTY

A. Warranty for the batteries and battery chargers shall be provided and signed by the manufacturer and installer agreeing to correct system deficiencies and replace components that fail in materials or workmanship.

B. Batteries shall have a warranty of one year from the date the battery is placed into revenue service and an additional warranty of 19 years, pro rata, to deliver not less than 80 percent of its rated capacity. The battery chargers shall have a warranty of one year from the date the battery charger is placed in service.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

A. The DC Control power system shall be manufactured by any of the following:

1. Alpha Industry Power
2. C and D Technologies
3. EnerSys
4. Kawasaki
5. Or equal

2.02 GENERAL

A. DC control power system shall include primary input circuit breaker, DC circuit breakers, isolation transformers, batteries, battery charger (AC-DC), voltage converters (DC-DC), batteries, battery rack, molded case circuit breakers, DC distribution panel, spill containment system, and related wiring and accessories as specified herein and the Contract Drawings.

B. The input voltage to the DC control power system shall be as indicated, single phase, 60 Hz. The output voltage shall be 125 V DC.

C. Ratings:

1. Ratings shall be determined by the Supplier.

2. The DC control power systems shall be designed for continuous operation at the specified rating, for 24 hours a day, 365 days a year operation.

3. The DC control power systems shall be sized per IEEE 485.

D. Environmental Conditions: The batteries and battery chargers shall be suitable for operation under the following ambient temperature ranges:

1. Operating Temperature Range: -7 degrees C to 40 degrees C

2. Maximum daily average temperature: 30 degrees C

E. DC control power systems shall be provided with neutralization consisting of a liquid-light spill-control barrier of sufficient volume and absorbent neutralizing pads of sufficient capacity to contain the electrolyte from the largest cell in the array and raise its pH to the range of 7.0 to 9.0.

F. Ground enclosure door(s) to the enclosure by means of a visible, flexible copper grounding strap.

G. Provide nameplates showing enclosure and component number.

H. Proper terminal identification shall be provided.

I. “Danger Electrical Hazard” warning signs shall be placed on access panels and doors.

J. Refer to the Contract Drawings, for additional identification requirements.

2.03 BATTERIES

A. The battery and its associated charger shall be connected in parallel. The charger, in addition to charging the battery, shall carry the continuous connected load. The battery shall supply the remainder of the heavy short-time current demands. When the AC supply to the charger is interrupted, the battery shall supply the required power for the specified load duty cycle.

B. The batteries shall be of heavy-duty, deep-cycle, maintenance free mono-block (multiple cells in a jar) design. The battery mono-blocks shall:

1. Be flooded lead-calcium with a minimum of 20 years design life under normal usage for the intended duty. Batteries shall be designed for float service.

2. Be valve-regulated lead acid type for portable substations, with a minimum of 20 years’ design life under normal usage for the intended duty. Batteries shall be designed for float service. Batteries shall not vent gas under normal operation.

C. Batteries shall consist of enough cells to provide specified output voltage. The battery shall accept a charging voltage as indicated with a tolerance of plus 12 percent (140 V DC) or minus 44 percent (70 V DC) as design operating range.

D. Batteries shall be able to support also one trip-close-trip cycle for 34.5 kV circuit breakers or vacuum fault interrupter, and 1200 V DC circuit breakers at any time during the 8-hour charger-down period, and provide acceptable operating voltage to 125-volt and 24-volt devices at the end of the period.

E. Batteries shall be rated to supply the high discharge rates necessary to close and trip electrically operated DC circuit breakers after the battery has supplied, without assistance from a charging source, the lower discharge rates required for the indicating lights, electronic relays and communication devices in the traction power facility, with the battery charger being out of service for eight hours.

F. Battery Capacity:

1. Determine the size of the batteries for each traction power facility in accordance with IEEE 485.

2. Batteries shall have ampere-hour capacity to provide rated power and acceptable voltage to connected equipment and devices for eight hours.

3. Battery capacities shall be adequate for the following load duty cycle over a period of eight hours from a fully charged state with the battery charger out of service:

    a. Normal continuous demand of traction power facility’s ancillary loads including relays, indicating lamps, control and annunciator panel, and supervisory control circuits.

    b. After eight hours, trip, close, and trip AC and all DC circuit breakers of the TPSS.

    c. Each positive and negative cell assembly shall be designed for the required battery duty and a long-life cycle. Cell elements shall be supported from projections in the bottom of the cell container or from the cover.

G. Cells shall have a specific gravity range as indicated in manufacturer’s recommendation plus or minus 0.02 at 77 degrees Fahrenheit, when fully charged.

H. Cells shall be provided with insulated intercell connectors. Batteries shall be provided with terminal plates and lugs as required. Connectors, plates, and lugs shall be lead-plated solid copper. Hardware shall be stainless steel hex nuts and washers. Provide non-conductive covers for battery terminals.

I. Cell Containers:

1. The individual cell housing shall be molded, heat-resistant, flame-retardant, durable, impact resistant cases and shall not deteriorate or become cloudy upon exposure to the electrolyte.

2. The cell covers shall be cemented in place to provide a permanent leak-proof seal.

3. Polarity of cell terminal posts shall be clearly and permanently identified.

4. Electrolyte level lines shall be marked on all four sides of the cell housing.

5. Each cell shall be provided with a filler opening fitted with an explosion resistant vent.

6. Each battery cell container shall be legibly and permanently marked with the following information:

   a. Manufacturer's name.

   b. Battery type.

   c. Cell number and type.

   d. One-minute, one-hour, and eight-hour ampere ratings.

   e. Month and year of manufacture.

   f. Ampere-hour capacity.

J. Nameplates: Each battery shall be legibly and permanently marked with the following:

1. Manufacturer's name.

2. Battery and cell type.

3. One-minute, one-hour, and eight-hour ampere ratings.

4. Month and year of manufacture.

5. Ampere-hour capacity for eight hours.

2.04 BATTERY CHARGERS

A. Battery chargers shall be completely automatic, silicon-controlled rectifier, convection cooled, and constant voltage, complying with NEMA PE 5.

B. Battery charger enclosure shall be NEMA 250, Type 1. Enclosure shall be provided with a hinged front panel complete with lockable handle and two-point latches, minimum.

C. The chargers, in addition to charging the battery, shall carry the continuous load and non-continuous current demands such that battery charger can operate as a DC power supply without batteries, and without affecting the normal operation of any of the equipment that is supplied by the DC battery system.

D. Battery chargers shall be rated as follows:

1.	Capacity	In accordance with its associated battery size and continuous DC load.
2.	Recharging	Shall be able to recharge the battery from 1.75 V per cell to 85 percent of the battery capacity in 8 hours, maximum.
3.	Output Current:	In accordance with its battery size and continuous DC load.
4.	Regulation:	Plus or minus 1 percent of output DC voltage over its complete load range with plus or minus 10 percent variation of input AC voltage.
5.	Current Limiting:	Adjustable from 90 to 115 percent; factory set at 110 percent of output nominal current rating.

E. Each battery charger shall be furnished with the following accessories:

1. One DC voltmeter, 0 to 200 V.
2. One DC ammeter, range as applicable.
3. One AC input pilot light marked AC POWER ON.
4. One selector switch two positions marked FLOAT and EQUALIZE.
5. Two ground detection alarm relays, positive and negative, for local and remote supervisory annunciation.
6. One AC input molded-case circuit breaker, NEMA AB 1.
7. One DC output molded-case circuit breaker, NEMA AB 1.
8. One equalizing time charger, 0 to 72 hours, to terminate a manually set adjustable equalizing charge of 2.33 V per cell.
9. One DC failure alarm relay for local and remote supervisory annunciation.
10. One AC failure alarm relay for local and remote supervisory annunciation.
11. DC over voltage alarm relay.
12. Temperature compensated charging based on monitoring of battery temperature.
13. Surge and transient protection.
14. Current overcharging protection.
15. Space heaters.

2.05 DC/DC CONVERTERS

A. General: Subject to the equipment vendor's design, provide in each traction power facility a DC/DC converter with N+1 redundancy for reliability. DC/DC converters shall be of modular design with built-in automatic current sharing feature that provides the continued rated power output with failure of any one module. Converter design shall allow for "hot" replacement of modules. Key features of the DC/DC converter shall be as follows:

1. Input voltage: 125 V DC nominal. The converter's acceptable input voltage range shall be coordinated with the 125 V DC control power system, so that the batteries float voltage and deep discharge levels are within the acceptable limits.

2. Output voltage: Output voltage shall be per the Contract Drawings with adjustment capability.

3. Power rating: To be determined by the Contractor, so that the DC/DC converter provides a minimum of 25 percent spare capacity when operating in N modules configuration.

4. Efficiency: Eighty percent at full load, or higher.

5. Output Ripple/Noise: Less than 1.5 percent of the output voltage, peak to peak.

6. Operating Temperature Range: Minus 10 degrees C to plus 55 degrees C.

7. Protection: Over-voltage, over temperature, reverse input voltage.

8. Indications and Controls: At a minimum, each DC/DC converter module shall have local LED indications for normal operations, local and remote trouble alarms, and a means to adjust the output voltage level. Converter module failure shall be indicated to the C02 panel. Refer to Contract Drawings for additional requirements.

9. Meters: Voltmeter and ammeter for measuring voltage and current on the output side shall be provided. The meters may be either separate for each module, or common for the entire converter.

10. As shown on the Contract Drawings, the input side of each DC/DC converter unit circuit in the N+1 configuration shall be connected to an independent circuit breaker in the main 125V panel and shall utilize separate cables for the entire run from the main panel to the converter unit. The output side of the side of each DC/DC converter unit circuit in the N+1 configuration shall likewise be connected to an independent circuit breaker through separate cables.

2.06 BATTERY RACKS AND VENTILATION SYSTEM

A. Batteries shall be provided with two-tier two-step structural steel support racks. Battery racks shall be provided with insulating plastic strips to cover supports, hold-downs, and restraining rails that are in contact with the battery cells. The exposed perimeter of the battery racks shall be covered with removable non-metallic acid-resistant barriers to preclude storage of foreign metallic objects.

B. Battery racks and associated anchorage shall be designed to meet the seismic requirements as specified in Section 34 21 01, General Requirements for the Traction Power.

C. A forced air ventilation system composed of fan, ducting and an exterior hood, shall be provided to remove all potentially explosive gases from the traction power facility batteries and vent it directly to the outside. Hood shall effectively prevent backflow of wind through the louver.

D. Provide an airflow switch in the ventilation duct to disable the battery bank upon loss of ventilation. The air flow switch shall be provided with two (2) Form C contacts for activating the battery bank circuit breaker and to provide remote annunciation via SCADA.

2.07 DC DISTRIBUTION PANELBOARDS

A. Refer to Section 26 24 24, Circuit Breakers and Panelboards, for additional requirements.

B. DC panelboards shall be suitable for 2-wire, 125 V DC and 24V DC ungrounded power distribution service. Panelboard shall be equipped with main and branch circuit breaker type disconnects complying with NEMA PB1 certified to UL 67.

C. DC panelboard circuit breaker ratings shall be determined by the Supplier. Provide at least 20 percent spare of each branch circuit breaker rating and at least one of each size.

D. Panelboards shall be surface mounted, dead-front type, housed in a NEMA Type 12 steel enclosure with hinged front cover, lockable handle, and two-point latch, minimum.

E. A moisture resistant circuit identification typewritten chart with electrical loads, shall be provided and attached to the inside face of the cover.

F. Establish the required current rating of the control power distribution panelboards, including their supplied distribution loads for each DC control power system.

G. Each panelboard shall be provided with main incoming terminal lugs and main circuit breaker.

H. Panelboards shall be provided with the required number of branch circuit breakers, circuit breaker ratings and number of poles, based on the following control power distribution requirements:

1. 34.5 kV AC switchgear line-up or vacuum fault interrupter.
2. 1,200V DC switchgear.
3. Rectifier-transformers and rectifiers.
4. Control and HMI panel.
5. Cabinets.
6. Miscellaneous low voltage electrical loads associated with the traction power facility and adjacent electrical loads. Refer to Contract Drawings for additional requirements.

2.08 MOLDED CASE CIRCUIT BREAKERS

A. Provide two (2) two-pole molded case circuit breakers, one (1) circuit breaker to be installed between the set of batteries and the line side of the DC panelboard main circuit breaker and one (1) circuit breaker to be installed between the battery charger DC output circuit breaker and the line side of the DC panelboard main circuit breaker as indicated. The circuit breakers shall provide overload and short circuit protection for the battery system and main cables to the DC distribution panelboard. The circuit breakers rating shall be coordinated with the DC output circuit breaker of the battery charger. The circuit breakers shall be mounted in a NEMA Type 12 enclosure.

B. Nameplates shall be mounted on the front of the enclosure and shall contain identification of circuit breaker type, style number, and short circuit ratings.

C. Accessories:

1. Lugs: Suitable for number, size, and conductor material.

2.09 FINISHES

A. Battery racks shall be treated with at least two coats of acid and alkaline resistant paint.

B. Equipment shall be cleaned, primed, and finish painted in accordance with the manufacturer’s standard specifications, suitable for indoor service.

2.10 LOCAL AND REMOTE ALARM ANNUNCIATION

A. Provide local fault indications for each battery system as applicable:

1. Loss of 125V DC control voltage, Device No. 27.

2. Loss of 24V DC control voltage, Device No. 27.
3. Battery system overvoltage, Device No. 59.
4. Battery charger overload, Device No. 51.
5. Battery high temperature, Device No. 26.
6. Loss of battery ventilation air flow, Device No. 63 AF.
7. DC/DC converter module failure, Device Nos. 26, 46 and 59.
8. Ground fault detected, Device 64G.

B. Refer to the Contract Drawings for remote fault indications for DC control systems.

2.11 EMERGENCY EYE WASH

A. Refer to Section 22 40 00, Plumbing Fixtures for requirements.

B. For portable substations, provide a portable eye-wash unit with twin spray heads 38 liter stainless steel tank automatic pressure control, push-to-operate valve and pressure gauge. Product shall be in conference with CAL/OSHA Industrial Safety orders and ANSI/ISEA Z358.1.

2.12 SPILL CONTAINMENT SYSTEM

A. Electrolyte resistant spill containment system shall be provided under each battery rack, extending not less than 12 inches outside the rack.

2.13 ACCESSORIES

A. One set of the following accessories shall be provided at each traction power facility:

1. Removable, transparent, non-conductive battery rack guards shielding top and all sides of battery rack.
2. Thermometer.
3. Hydrometer with holder.
4. Filling syringe.
5. Cell lifting sling, complete with strap and spreader.
6. Battery logbook.
7. Quart of terminal grease.
8. Set of special tools, if required.
9. Set of cell identification numbers.

2.14 FACTORY ASSEMBLY

A. Fabricate each DC control power system with equipment, devices, accessories, and appurtenances in place for a fully functioning and operable DC control power system.

B. Arrange the battery and rack assembly to provide easy access to each battery cell for maintenance and replacement. No equipment shall be installed above the battery rack and within 12 inches of battery rack horizontal footprint.

C. The minimum unobstructed horizontal clearance between the DC control power system enclosure and adjacent equipment and structures shall comply with the NEC.

D. Install the DC control power system secure, level with stainless steel shims (if required), plumb and in true alignment with related adjoining work. Secure the DC control power system to the floor/wall in accordance with equipment vendor's recommendations and the approved seismic design.

E. Install supporting members, fastenings, framing, hangers, brackets, straps, bolts, and angles as required to set and rigidly connect the DC control power system.

F. Control erection tolerance requirements so as not to impair the strength, safety, serviceability, or appearance.

G. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not available, use those specified in UL 486 A and B.

2.15 FACTORY ACCEPTANCE TESTING

A. Refer to Section 34 21 80, Traction Power System Field Acceptance Testing, for additional requirements.

B. Prior to scheduling factory acceptance test to be witnessed by the Engineer, ensure:

1. Each DC control power system and enclosures are completely fabricated and assembled per the approved equipment vendor design.

2. Identifiers shall be installed.

3. DC control power systems shall be cleaned.

C. In addition to manufacturer's standard tests, perform factory tests on equipment provided under this Section in accordance with ANSI, NEMA, and IEEE standards. Check control and power wiring, correct connections against the approved Shop Drawings, insulation resistance, and freedom from shorts and grounds.

D. Batteries: Required factory tests specified in IEEE 450 and including the following:

1. Temperature rise test.
2. Power loading at 100 percent capacity for 24 hours at 90 degrees Fahrenheit and 90 percent humidity.

E. Battery Charger:

1. Functional test and demonstration of functions, controls, indicators, sensors, and protective devices.
2. Dielectric test.
3. Circuit operation test.
4. No-load test.
5. Full-load test.
6. Maximum output current test.
7. Transient-load response test.
8. Power failure test.

F. DC/DC Converter Test

1. Functional test and demonstration of functions, control, indicators, and protective devices.
2. Efficiency.
3. Input/output voltage levels.

2.16 WIRING, TERMINATIONS, AND CONDUIT WORK

A. Refer to the following Sections for requirements:

1. Section 20 50 13 Raceways for Facility Services.
2. Section 26 05 24 Low Voltage Wires and Cables.
3. Section 34 21 50 Common Materials and Methods for Traction Power.

2.17 GROUNDING

A. Refer to Section 34 21 60, Grounding and Bonding for Traction Power Facilities, for the grounding and bonding requirements.

PART 3 – EXECUTION

3.01 FIELD INSTALLATION

A. DC control power system, materials, and appurtenances shall be installed as recommended by the manufacturer.

B. Refer to the following Sections for additional requirements:

1. Section 26 24 24 Circuit Breakers and Panel Boards.

C. Provide anchor bolts and anchorage items as required, and field check to ensure proper alignment and location. Provide templates, layout drawings, and supervision at the Jobsite to ensure correct placing of anchorage items in pre-engineered building or on concrete for equipment delivered loose. Check embedded items for correctness of location and detail before concrete is placed.

D. Confirm the DC control power system equipment and associated materials are in conformance with the approved Shop Drawings prior to placement.

E. Install the DC control power system secure, level with stainless steel shims (if required), plumb and in true alignment with related adjoining work. Secure the DC control power system to the floor/wall in accordance with equipment vendor's recommendations and the approved seismic design.

F. Install supporting members, fastenings, framing, hangers, brackets, straps, bolts, and angles as required to set and rigidly connect the DC control power system.

G. Provide temporary bracing, guys, and other devices as required accomplishing erection and to provide safety and stability until work is in final position and approved.

H. Control erection tolerance requirements so as not to impair the strength, safety, serviceability, or appearance.

I. The DC control power system located in damp or wet locations, shall be placed and equipped so as to prevent moisture or water from penetrating and accumulating within the enclosure.

J. The minimum unobstructed horizontal clearance between the DC control power system enclosure and adjacent equipment and structures shall comply with the NEC and CEC.

K. Arrange the battery and rack assembly to provide easy access to each battery cell for maintenance and replacement. No equipment shall be installed above the battery rack and within 12 inches of battery rack horizontal footprint.

L. Verify the DC control power system and associated materials are correctly installed in accordance with the approved installation manual and drawings.

M. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not available, use those specified in UL 486 A and B.

N. Protect the DC control power system and associated materials during field installation and field testing activities. Repair or replace items damaged at no cost.

O. Complete the installation and cleaning of the DC control power system, associated materials and conduits before starting wire/cable installation.

P. Thoroughly clean the DC control power system per the manufacturer's recommendations prior to installation verification and field testing.

Q. Interconnect indication functions specified in this Section to the C02 panel for local and remote operation/monitoring. Refer to the Contract Drawings and Section 34 21 33, Traction Power Control, Monitoring and Display Panel, for additional requirements.

R. Refer to Section 34 21 70, Traction Power Facilities Installation Requirements, for additional requirements.

3.02 FIELD TOUCH-UP

A. Remove paint splatters and other spots.

B. Clean and repaint damaged interior and exterior surface coatings of the DC control power system enclosures and racks with the same coating system used in the factory, using touch up paint provided by the manufacturers.

C. Painting shall follow closely the recommendations of the paint manufacturers. Provide the appearance of a new installation prior to Acceptance.

3.03 INSTALLATION VERIFICATION, FIELD FUNCTIONAL AND SYSTEM INTEGRATION TESTING

A. Refer to Section 34 21 80, Traction Power System Field Acceptance Testing, for requirements.

3.04 CLEANING

A. Refer to Section 01 74 14, Cleaning, for additional requirements.

3.05 DEMONSTRATION AND TRANING

A. Refer to Section 01 79 00, Demonstration and Training for additional requirements.

B. Supplier shall ensure that a factory-authorized service representative provides equipment demonstration and training for the District's maintenance personnel to adjust, operate, and maintain the DC control power system and associated equipment.

3.06 CLOSEOUT PROCEDURES

A. Refer to Section 01 77 00, Closeout Procedures; and Section 01 78 39, Project Record Documents, for requirements.

END OF SECTION 34 21 40

SECTION 34 21 50

COMMON MATERIALS AND METHODS FOR TRACTION POWER

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Buses and Connections

B. MV Cables, Boots, Connectors, Splice and Termination Hardware, and Fire and Arc Proof Tape

C. Low Voltage Dry Type and Isolating Transformers

D. Low Voltage Molded Case Circuit Breakers

E. Fiber Optic Transceivers/Media Converters

F. Fiber Optic Cables, Splice Hardware and Connectors, and Patch Panels

G. Lamp Holders and Light Fixtures

H. Meters and Relays

I. Transducers

J. Switches

K. Indicating Lights

L. Low Voltage Wires and Cables

M. Conduits, Cable Trays, Underground Ductbanks, Boxes and Mounting Hardware

N. Wiring Devices and Covers

O. Termination Blocks

P. Low Voltage Connectors and Insulating Tape

Q. Grounding and Bonding

R. Sleeves & Associated Seals

S. Fire Stopping System

T. Miscellaneous Devices

1.02 RELATED SECTIONS

A. Refer to the following Sections for requirements:

1. Section 01 33 00 Submittal Procedures
2. Section 01 33 23 Shop Drawings, Product Data, and Samples
3. Section 01 78 23 Operations and Maintenance Data
4. Section 20 50 13 Raceways for Facility Services
5. Section 20 50 16 Underground Ductwork and Structures for Facility Services
6. Section 23 81 00 Unitary HVAC Equipment
7. Section 26 05 17 Dry-Type Transformers
8. Section 26 05 24 Low Voltage Wires and Cables
9. Section 26 05 26 Grounding and Bonding
10. Section 26 24 24 Circuit Breakers and Panelboards
11. Section 26 50 00 Lighting
12. Section 27 13 01 Communication Cables and Related Equipment
13. Section 34 21 01 General Requirements for the Traction Power System
14. Section 34 21 19 Separable Insulated Connectors
15. Section 34 21 55 Manual DC Disconnect Switch
16. Section 34 21 56 34.5KV Isolation Disconnect Switches
17. Section 34 21 60 Grounding and Bonding for Traction Power Facilities
18. Section 34 21 70 Traction Power Facilities Installation Requirements
19. Section 34 21 75 Traction Power Facility System Factory Functional Testing
20. Section 34 21 80 Traction Power System Final Acceptance Testing
21. Section 34 22 23 Traction Power Cables

1.03 MEASUREMENT AND PAYMENT

A. Separate measurement and payment will not be made for work required under this Contract Specifications Section. All costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM B766 Standard Specification for Electrodeposited Coatings of Cadmium

2. ASTM E84 Standard Test for Surface Burning Characteristics of Building Materials

B. International Electrotechnical Commission (IEC)

1.	IEC 60051-1	Direct Acting Indicating Analogue Electrical Measuring Instruments and Their Accessories- Part 1: Definitions and General Requirements Common to All Parts
2.	IEC 60051-4	Direct Acting Indicating Analogue Electrical Measuring Instruments and Their Accessories Part 4: Special Requirements for Frequency Meters
3.	IEC 60051-5	Direct Acting Indicating Analogue Electrical Measuring Instruments and Their Accessories Part 5: Special Requirements for Phase Meters, Power Factor Meters and Synchroscopes
4.	IEC 60051-6	Direct Acting Indicating Analogue Electrical Measuring Instruments and Their Accessories Part 6: Special Requirements for Ohmmeters (Impedance Meters) and Conductance Meters
5.	IEC 60051-7	Direct Acting Indicating Analogue Electrical Measuring Instruments and Their Accessories Part 7: Special Requirements for Multi-Function Instruments
6.	IEC 60051-8	Direct Acting Indicating Analogue Electrical Measuring Instruments and Their Accessories Part 8: Special Requirements for Accessories
7.	IEC 60051-9	Direct Acting Indicating Analogue Electrical Measuring Instruments and Their Accessories Part 9: Recommended Test Methods

C. Institute of Electrical and Electronics Engineers (IEEE):

1.	IEEE C37.90	Standard for Relays and Relay Systems Associated with Electric Power Apparatus
2.	IEEE C37.90.1	Standard for Surge Withstand Capability (SWC) Tests for Relay and Relay Systems Associated with Electric Power Apparatus
3.	IEEE C57.13	Relay Requirements for Instrument Transformers

4. IEEE 383 Standard for Type Test of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations

D. National Electrical Manufacturers Association (NEMA):

1. NEMA C12.1 Electric Meters – Code for Electricity Metering

2. NEMA FG 1 Fiberglass Cable Tray Systems

3. NEMA VE 1 Metallic Cable Tray Systems

E. National Fire Protection Agency (NFPA):

1. NFPA 70 National Electrical Code

F. Underwriters Laboratories Inc. (UL):

1. UL 94 Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

1.05 SUBMITTALS

A. Refer to the following Sections for additional requirements:

1. Section 01 33 00 Submittal Procedures

2. Section 01 33 23 Shop Drawings, Product Data, and Samples

B. Submit:

1. Data sheets for conduit support bracing, conduits and raceway accessories.

2. Product data for meters, relays, instrument transformers, transducers, control switches, low voltage and communication wiring and cables, raceways and miscellaneous auxiliary devices.

3. Operations and Maintenance Manuals: Provide Operations and Maintenance Manuals in accordance with Section 01 78 23, Operations and Maintenance Data. Standard off the shelf manuals shall be submitted as Pre-Final Manuals.

1.06 QUALITY ASSURANCE

A. Refer to Section 34 21 01, General Requirements for the Traction Power System, and Section 34 21 70, Traction Power Facilities Installation Requirements, for requirements.

B. Electrical components, devices, and accessories shall be listed and labeled in conformance with NFPA 70, Article 100.

1.07 DELIVERY, STORAGE AND HANDLING

A. Refer to Section 34 21 70, Traction Power Facilities Installation Requirements, for requirements.

1.08 GENERAL REQUIREMENTS FOR THE TRACTION POWER SYSTEM

A. Refer to Section 34 21 01, General Requirements for the Traction Power System, for requirements.

PART 2 – PRODUCTS

2.01 BUSES AND CONNECTIONS

A. Buses shall be made of round edge rectangular, high conductivity, rigid copper bars and shall be of sufficient size to carry the continuous rated current, without exceeding the temperature limits indicated in the applicable ANSI, NEMA, and IEEE standards for the specific equipment.

B. The buses shall be supported and braced between each other and to the enclosure with high strength anti-hygroscopic, flame retardant, non-tracking insulators, so that the buses can withstand the thermal and mechanical stresses due to short-circuit currents equal to the maximum symmetrical interrupting and three-second short time current ratings of the circuit breaker protecting the bus.

C. Bus taps and connections shall be welded or bolted:

1. All bolted bus connections shall be acid etched and plated with electro-deposited silver after buses have been bent or formed. Bending after the plating process is not allowed.

2. Bolted connections shall utilize Bellville-type washers and high strength, rust resistant steel bolts, such as cadmium-plated or galvanized. Bolts shall pass through the bus bar conductors, and shall be capable of being properly torqued and locked in place, to provide and maintain full and uniform pressure under all operating conditions.

D. Bus joints shall have conductivity at least equal to that of the bus bar, and each joint shall be so clamped that no loss of conductivity will occur during the life of the equipment.

E. Access plates shall be provided to permit assembling joints and inspecting all bolted connections after installation of the bus enclosure.

2.02 MV CABLES (35 KV, 2400 V), BOOTS, CONNECTORS, SPLICE AND TERMINATION HARDWARE, FIRE AND ARC PROOF TAPE

A. Refer to Section 34 21 19, Separable Elbow Connectors and Section 34 22 23, Traction Power Cables, for product and installation requirements.

2.03 LV DRY TYPE POWER AND ISOLATING TRANSFORMERS

A. Refer to Section 26 05 17, Dry Type Transformers, for product and installation requirements.

2.04 LV MOLDED CASE CIRCUIT BREAKERS

A. Refer to Section 26 24 24, Circuit Breakers and Panelboards, for product and installation requirements.

2.05 FIBER OPTIC TRANSCEIVERS/MEDIA CONVERTERS

A. Refer to Section 27 13 01, Communication Cables and Related Equipment, for product and installation requirements.

2.06 FIBER OPTIC CABLES, SPLICE HARDWARE AND CONNECTORS, PATCH PANELS

A. Refer to Section 27 13 01, Communication Cables and Related Equipment, for product and installation requirements.

2.07 LAMP HOLDERS AND LIGHT FIXTURES

A. Refer to Section 26 50 00, Lighting, for product and installation requirements.

2.08 METERS AND RELAYS

A. Metering and relaying devices, and similar devices, shall be provided, wired, and connected as indicated.

B. Additional components, such as auxiliary relays, isolating diodes, and other devices not indicated but required for a complete fully functional system, shall be furnished and installed.

C. Each relay and device shall have a sealed dust cover, which shall keep the inside of the case free of dust and moisture.

D. Protective devices provided shall prevent damage to the individual parts of the equipment due to short-circuit, loss of cooling, transient voltage conditions and overloads.

E. All protective relays in the AC switchgear and DC switchgear shall be solid-state type. Control and auxiliary relays shall be electro-mechanical type. Solid-state type auxiliary relays are acceptable provided their output contacts, if required to interface with other systems such as SCADA, are independent and potential free:

1. Unless stated otherwise, relays requiring control power shall be able to operate properly with station battery voltage of 125 V DC, with fluctuations of plus or minus ten percent.

2. All relay contacts shall be properly rated for the intended duty, and shall meet the required performance with no less than 50 percent spare margin at the expected worst-case operating condition.

F. All protective relaying shall be provided with separate contacts for each operating element, and shall have indicating targets to show operation of the relay element. Drawout type relays shall be installed in their cases prior to final inspection and shipment.

G. All protective devices shall be coordinated to prevent false tripping or malfunction, to protect against damage to equipment, property, and personnel, and to assure continuity of operation.

H. Relays and devices suitable for semi-flush mounting shall be of the flexitest-type or of the drawout type with flat black finish and shall be mounted on panels or doors.

I. Relays and devices not suitable for semi-flush mounting shall be surface mounted to mounting brackets on panels within enclosures or on the inside of the doors.

J. Indicating instruments shall be semi-flush mounted on the front panels and shall have LED readouts.

K. Relays and devices in which any of the elements are subjected to 1,000 V DC potentials shall be mounted on an insulating base inside the high voltage compartment.

L. Solid state relays shall be of the Schweitzer Engineering Laboratories, Inc. (SEL), Basler Electric, General Electric or approved equal.

M. Lockout Relays:

1. Lockout relays shall be high-speed, multi-contact, hand reset type with oval handles and mechanical targets which indicate whether the relays are in the tripped or reset position.

2. Lockout relays shall be Electroswitch Series 24, General Electric Type HEA, Westinghouse Type WL, or approved equal.

N. Interposing (Auxiliary) Relays:

1. Interposing (auxiliary) relays shall be plug-in type and include dust covers and be rated for ten amperes.

2. Relay coil shall be able to pickup by momentary contact closure of 300 ms and its contacts shall stay closed until the circuit breaker or the end device completes its operation. If operation is not completed within the normal time, the relay coil shall reset automatically.

3. Contractor shall coordinate with BART engineer the duration of the remote control signals from the District's OCC with the pickup times of the interposing

relays in the traction power facilities to ensure the remote commands do reach and activate the end device of the intended equipment.

O. Meters: All meters shall be switchboard type for semi-flush mounting. The cases shall be dust tight, with dull black finish, and covered with a non-reflecting glass window:

1. Ammeters, wattmeters, watthourmeters, varhour meters and voltmeters shall be solid-state type with digital LED readouts that cover the full range of operation including overload conditions. The LED readouts wattmeters, watthour meters and varhour meters shall be able to read nine digits and self-reset to zero after maximum reading is reached. The ammeters and voltmeters shall be able to read 6 digits.

2. The accuracy of all indicating instruments shall be within one-half percent of the actual value. The indicating instruments shall have true RMS sensing.

3. AC voltmeters at the 34.5 kV AC circuit breakers, either in the form of digital display of the incoming voltage on the IPR or as separate voltmeters. The calibration shall be line-to-line voltage. The metering data shall be sent also for remote indication on the CO2 panel in the DC house, from where the data shall be re-transmitted to the BART maintenance computers. The scan rate for remote indication shall be one second or less. DC voltmeters shall receive inputs from voltage transducers via the CO2 PLC, as indicated.

4. AC ammeters at the 34.5 kV AC circuit breakers, either in the form of digital display on the IPR of the current flowing through the incoming line monitored by the IPR, or as separate ammeters. Provide capability of monitoring the current of each phase. The metering data shall be sent also for remote indication on the CO2 panel in the DC house, from where the data shall be re-transmitted to the BART maintenance computers. The scan rate for remote indication shall be one second or less. DC ammeters shall receive inputs from metering shunts, via current transducers and the CO2 PLC, as indicated.

5. Ammeter and voltmeter switches to monitor the three-phase ac current and voltage, respectively, shall be provided.

6. Wattmeters shall be rated on a mA for connection to wattmeter transducers.

7. The watthour and varhour meters shall have drawout construction and shall be transformer rated, 120 V, 5 A, with suitable range equal to the associated potential and current transformers. The meters shall be furnished with an accumulator.

2.09 TRANSDUCERS

A. General: Except for the AC watt-hour and var-hour transducers specified in Article 2.09D below, and the isolation transducer for the DC MPR, output range of all transducers shall be either four to 20 mA, or zero to five V signals.

B. AC Current Transducers:

1. Operating input range shall be single phase, zero to five amperes, 60 Hz with overload capability of 20 amperes continuous and 250 amperes for 1.0 second.

2. Burden shall not exceed 2.0 VA at 60 Hz.

C. AC Voltage Transducers:

1. The nominal input voltage to each ac voltage transducer shall be single phase, 120 V, 60 Hz. The operating input range shall be 0 to 150 V AC with continuous overload capability to 180 V AC.

2. Burden shall not exceed 2.5 VA at 120 V AC, 60 Hz.

3. The maximum allowable error shall not exceed plus or minus 0.25 percent of full scale at 25 degrees Celsius. AC output ripple shall not exceed one percent.

4. The error resulting from a temperature variation between minus 20 degrees Celsius and 60 degrees Celsius shall not exceed plus or minus 0.5 percent of full scale.

5. The unit shall be provided with a ten percent of full-scale calibration adjustment. The response time shall be 400 ms or better from 0 to 99 percent.

6. The unit shall withstand a dielectric test of 1,500 V RMS.

D. AC Watthour and Varhour Transducers:

1. The potential input to the watthour and varhour transducers shall be 120 V AC, 60 HZ nominal, 0 to 150 V operating range, 180 V overload and 4 VA burden at nominal voltage.

2. The current input shall be five amperes nominal, 0 to 20 amperes operating range, 250 amperes overload for one second and 0.25 VA burden.

3. The maximum allowable error shall not exceed plus or minus 0.2 percent of full scale at 25 degrees Celsius. The transducer shall be provided with a ten percent of full-scale calibration adjustment. The full-scale calibration shall be rated in accordance with the instrument transformer (potential or current) ratios.

4. The response time shall be 400 ms or better from 0 to 99 percent range.

5. Signal from transducers shall be pulses that can be sensed by a SCADA discrete input module. Transducers shall be calibrated so that each pulse represents a given number of KWH or KVARH units. Pulse rate at normal full load shall not exceed one pulse per second. Pulse duration shall be more than 100 ms and less than 150 ms.

E. Temperature Transducer:

1. The temperature input range shall be coordinated with type of Resistance Temperature Detector (RTD) supplied with the rectifier transformer.

2. The output range shall be suitable for the temperature class of the rectifier transformers.

F. DC Voltage Transducers:

1. DC voltage transducers shall be insulated for operation at 4,600 V dc for one minute. The operating input range shall be 0 to 1,500 V DC.

2. The maximum allowable error shall not exceed plus or minus 0.5 percent of full scale at 25 degrees Celsius. Temperature coefficient shall not exceed plus or minus 0.04 percent per each degree Celsius. Load resistance variations from 0 to 10,000 ohms shall affect the output current no more than 0.1 percent.

3. The input circuit shall be completely isolated from all other circuits and grounds. The output circuit shall include internal filtering.

4. Zero and gain adjustments shall be accessible from outside the case.

2.10 SWITCHES

A. Control and Selector Switches:

1. Control and selector switches shall be rotary, cam-operated, multi-stage type, suitable for switchboard mounting with a rectangular, front panel engraved escutcheon plate showing the switch positions. The switches shall be Electroswitch Series 24, Westinghouse type W-2, or General Electric type SB-1, or approved equal.

2. Control switches shall have the following types of handles:

   a. Circuit breaker control switches shall have pistol-grip handles.

   b. Instrument selector switches shall have round knurled handles.

   c. Local-remote transfer selector switches shall have oval handles.

3. Switch contacts shall be silver-plated, self-cleaning, readily renewable type, and shall have adequate insulation and contact surface. Switches shall be installed so that mating contact surfaces are parallel.

4. Breaker control switches shall be spring-return to neutral type with pull and lockout position, and shall be furnished with mechanical indicating devices (red and green target) to show the last operation of the switch.

5. The Contractor shall determine the number of stages and contact wiring arrangement for each switch, depending on the application. Each switch shall be provided with at least two spare stages.

6. Switches shall be rated for a mechanical life of not less than 500,000 operations. Electrical ratings shall be 600 V, 20 A continuous.

7. Tight-fitting dust covers shall keep the operating and contact parts of the switches clean.

B. Test Switches:

1. Test switches shall be provided for all ammeters and voltmeters, and between all instrument transformers and the protective relays supplied by these transformers.

2. Each test switch group shall be mounted in a semi-flush case of uniform size, capable of holding at least six current positions and four voltage positions. A convenient, dull black cover shall permit covering the test switches and contacts when they are not in use.

3. At the switching stations, test switches in current transformer circuits shall be seven-pole, with three straight test jack assemblies, one through bar, and three single-pole current assemblies, left hand, working as one unit.

4. Test switches for the current transformers shall be of the type that do not disturb the permanent wiring and do not interrupt the current transformer circuit when the switch is used

5. The test switches shall be specifically designed for use in AC instrumentation circuits, and shall be UL listed. Test switches shall be by States, Superior, Meter Devices, or approved equal.

6. Test switch shall be used to isolate current and voltage inputs to the protective relays and to cut-off relay trip output.

2.11 INDICATING LIGHTS

A. Indicating lights for equipment in the traction power facilities shall be based on light emitting diode (LED) lamps. The LED lamps shall be replaceable, with built-in resistor and high dielectric strength for reverse voltage protection. The LED lamps shall be:

1. Suitable for use with 125 V DC control system voltage;

2. Capable of operating over a voltage range from plus 15 percent to minus 30 percent of the nominal;

3. Designed with bayonet bases;

4. Mounted in compact, rugged sockets; and

5. Readily replaceable from the front.

B. Lenses and bezels shall be rectangular or circular, 1-3/8 inch maximum width and height and shall permit reading from oblique angles.

C. LEDs shall be rated for 100,000 hours at full voltage, and shall be clearly visible at an angle of 30 degrees and at 15 feet in a fully lit environment.

2.12 LV WIRES AND CABLES

A. Refer to Section 26 05 24, Low Voltage Wires and Cables, and Section 34 21 70, Traction Power Facilities Installation Requirements, for product and installation requirements.

2.13 CONDUITS, CABLE TRAYS, UNDERGROUND DUCTBANKS, BOXES AND MOUNTING HARDWARE

A. Refer to Section 20 50 13, Raceways for Facilities Services, and Section 20 50 16, Underground Ductwork and Structures for Facility Services, for the product requirements relating to raceways, cable trays, underground ductbank, mounting hardware, fittings and appurtenances.

2.14 WIRING DEVICES (I.E. RECEPTACLES, TOGGLE SWITCHES & OCCUPANCY SENSORS) AND COVERS

A. Refer to Section 20 70 26, Common Materials and Methods for Electrical Systems and Section 26 50 00, Lighting, for product and installation requirements.

2.15 TERMINATION BLOCKS

A. Refer to Section 20 70 26, Common Materials and Methods for Electrical Systems, for product and installation requirements.

2.16 LV CONNECTORS AND INSULATING TAPE

A. Refer to Section 20 70 26, Common Materials and Methods for Electrical Systems, for product and installation requirements.

2.17 GROUNDING AND BONDING (CONDUCTORS AND MATERIALS)

A. Refer to Section 34 21 60, Grounding and Bonding for Traction Power Facilities, for product and installation requirements.

2.18 MISCELLANEOUS DEVICES

A. Space Heaters: Thermostatically- and humidistatically-controlled space heaters shall be provided in all enclosures, and in separate compartments within enclosures, to keep the equipment temperature above the dew point and avoid condensation. Space heaters shall operate from the 120 V, single-phase, 60 Hz supply, and the

circuits shall be protected by circuit breakers. Space heaters shall be provided with laminated phenolic nameplates.

B. Current Shunts: Current shunts shall be used to provide dc millivolt signals as input to current measuring instruments and relays, as indicated. Current shunts shall be of rugged design and suitable for in-line busbar mounting. Shunt output shall be 50 mV nominal, with accuracy plus or minus 0.25 percent. The Contractor shall determine the current rating of the shunt, as suitable for the application.

PART 3 – EXECUTION

3.01 FACTORY TESTING

A. Refer to Section 01 45 24, Testing Program Requirements and Section 34 21 75, Traction Power Facility Factory Functional Testing, for additional requirements.

B. Test Types: Unless otherwise indicated, design tests on common materials and methods for the Traction Power System that are standard products of manufactures or off-the-shelf items that have not been specifically configured (hardware / firmware and/or software) to meet the District's requirements for this Contract, are not required. Production tests shall be performed in accordance with the requirements defined herein, and as needed to ensure a correctly assembled and properly functioning installation.

C. Relays, Meters, Transducers and Instrument Transformers:

1. Relays, meters, transducers and instrument transformers shall be tested in the factory for accuracy, performance, operation, and correct setting and calibration, per NEMA C12.1, IEEE C37.90, IEEE C39.1 and IEEE C57.13. The Contractor shall be responsible for relay coordination.

2. Relay and transducer testing, setting, and calibration shall be separately bench-tested from the overall inspection and testing. Relays and transducers shall be tested in accordance to IEEE C37.90.1 for surge withstand capability, except where certified test reports are available for the same model to prove that such tests have been passed successfully by identical equipment.

3. Test current and voltage shall be injected into the current and voltage circuits at the instrument transformer terminals to ensure that the protective relays are polarized correctly and trip the respective circuit breakers as designed, and to ensure that instruments read correctly and meters are calibrated accurately.

4. Instruments and transducers shall be checked for accuracy at quarter, half, three-quarters and full-range points.

5. After the relays have been calibrated with the proper settings, provide the following:

a. Solid state relays: Provide a sheet stating settings and date of calibration in a plastic jacket mounted in the relay cabinet or on the wall adjacent to the switchgear.

b. Electromechanical relays: Provide a small white card stating the settings and date of calibration placed in the relay case.

D. Factory Installed Low Voltage Wires and Cables:

1. Verify in the factory that the wiring conforms to the approved control schematics and wiring diagrams. Wiring continuity and proper termination shall be checked completely, including interconnections at shipping splits.

2. All wiring within equipment enclosures, and among equipment enclosures shall be tested as described below:

a. All wiring shall be checked for accuracy, intended functionality, ground connections, and insulation integrity by means of high potential, continuity, and operations tests.

b. All 1,000 V DC wiring shall be given a high-potential test of 6,800 V DC or 4,600 Vac, 60-Hz voltage to ground for one minute. All other low voltage wiring shall be subjected to 1,500 V, 60-Hz voltage to ground for one minute.

c. Insulated cables and wires shall be certified to have passed the design and production test in accordance with the applicable ICEA, IEEE and NEMA standards, including the flame propagation test.

3.02 INSTALLATION

A. Refer to Section 34 21 01, General Requirements for the Traction Power System, and Section 34 21 70, Traction Power Facilities Installation Requirements, for additional requirements.

B. Installation of common materials and methods for traction power shall conform to the recommended practices of the applicable ANSI, IEEE and NEMA standards; shall be in accordance with the accessibility, clearance, conformity, and arrangement requirements of Section 34 21 01, General Requirements for the Traction Power System, Section 34 21 70, Traction Power Facilities Installation Requirements, and as indicated.

C. Where interior or exterior GRS conduits containing 1,000 V DC system positive and negative cables are installed within one foot of each other, or in parallel with GRS grounding system conduits, provide conduit bracing of sufficient strength to inhibit distortion due to mechanical forces generated by DC system faults of 100,000 amperes.

END OF SECTION 34 21 50

SECTION 34 21 60

GROUNDING AND BONDING FOR TRACTION POWER FACILITIES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Grounding and bonding equipment.

B. Grounding rods.

C. Bare conductors.

D. Bus bar of ground test station.

E. Single conductor insulated wire.

F. Terminal lugs.

G. Jumpers.

H. Bolts and miscellaneous hardware for grounding.

I. Safety ground wire mesh.

J. Fiberglass reinforced thermoset polyester molded material.

1.02 RELATED SECTIONS

A. Section 01 43 00, Quality Assurance

B. Section 01 45 00, Quality Control

C. Section 01 71 23, Field Engineering

D. Section 01 33 00, Submittal Procedure

E. Section 01 33 23, Shop Drawings, Product Data, and Samples

F. Section 01 74 14, Cleaning

G. Section 01 77 00, Closeout Procedures

H. Section 01 78 39, Contract Record Documents

I. Section 01 79 00, Demonstration and Training

J. Section 01 45 24, Testing Program Requirements, for requirements

K. Section 20 70 26, Common Material and Methods for Electrical System

L. Section 20 80 00, Systems Integration Testing

M. Section 34 21 01, General Requirements for the Traction Power System

N. Section 26 05 24, Low Voltage Wires and Cables

O. Section 34 21 50, Common Materials and Methods for Traction Power

P. Section 34 21 70, Traction Power Facilities Installation Requirements

Q. Section 34 21 80, Traction Power System Field Acceptance Testing

1.03 MEASUREMENT AND PAYMENT

A. General: Grounding and bonding will be measured for payment for each installation that is furnished and for which testing is approved in accordance with the Contract Drawings and Technical Specifications.

B. Payment: Grounding and bonding will be paid for at the Contract unit price for each installation as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. American National Standards Institute (ANSI):

1. ANSI Z55.1 Grey Finishes for Industrial Apparatus

B. American Society for Testing and Materials (ASTM):

1. ASTM A780 Standard Practice for Repair of Damaged and Uncoated Areas of Hot Dip Galvanized Coatings
2. ASTM B3 Specification for Soft or Annealed Copper Wire
3. ASTM B187 Specification for Copper Bar, Bus Bar, Rod and Shapes
4. ASTM D495 Standard Test Methods for High Voltage, Low Voltage Arc Resistance of Solid Electrical Insulation

C. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE 80 IEEE Guide for Safety in AC Substation Grounding
2. IEEE 81 IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System
3. IEEE 142 IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems
4. IEEE 837 Qualifying Permanent Connections Used in Substation Grounding

5. IEEE 1100 IEEE Recommended Practice for Power and Grounding Electronic Equipment

D. Underwriters Laboratories Inc. (UL):

1. UL 486 A & B Wire Connectors

2. UL 467 Grounding and Bonding Equipment

E. California Code of Regulations:

1. Title 24, Part 3 California Electrical Code

F. National Electrical Manufacturers' Association (NEMA):

1. VE 1 Metal Cable Tray Systems

2. VE 2 Cable Tray Installation Guidelines

G. National Electrical Contractors' Association (NECA):

1. NECA 607 Standard for Telecommunications Bonding and Grounding Planning and Installation Methods for Commercial Buildings

H. National Electrical Safety Code

I. National Fire Protection Association (NFPA) Standards:

1. NFPA 70 National Electrical Code

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit detailed Shop Drawings including, but not limited to, the following:

1. Master Drawing Index.

2. Grounding Power Analysis Study Report

3. Grounding grid plans depicting locations of ground rods, embedded and buried grounding conductors, ground wells, locations of stub outs and grounding connections, safety wire mesh mats and locations of stub outs and pigtails for future connections to the grounding system by others. Plans shall show equipment layout.

4. Exposed grounding plans depicting locations of ground test stations, ground risers, and ground conductor routing.

5. Typical grounding details showing electrical systems, equipment, metallic conduit/cable tray and noncurrent carrying conductive entity grounding and bonding connection.

6. Drawings shall indicate locations of test points to measure grounding resistance.

C. Product Data: Submit manufacturer's product data sheets including, but not limited to, the following:

1. Ground conductors.

2. Connectors, clamps, terminal lugs, bushings, and fittings.

3. Exothermic welding process, materials, and molds.

4. Ground rods.

5. Ground test stations/busbars.

6. Ground well boxes.

7. Standoff insulators.

8. Flexible braid jumpers.

9. Coal tar epoxy coating.

10. Oxide inhibiting compound.

11. Safety ground wire mesh, if used.

D. Material safety data sheets.

E. Test Plans and Procedures: Submit test plans and procedures.

F. Test Reports: Submit required copies of certified test reports of grounding resistance tests, including method of measurement.

G. As-built and Records Drawings: Submit as-built and record drawings.

1.06 QUALITY ASSURANCE, QUALITY CONTROL AND SUPPLIER QUALIFICATIONS

A. Refer to Section 34 21 01, General Requirements for the Traction Power System.

1.07 DELIVERY, STORAGE AND HANDLING

A. Provide marking on wire and cable in accordance with applicable standards. Each item shall be UL-labeled.

B. Ship each item of equipment and materials securely wrapped, packaged, and labeled for safe handling in shipment and to avoid damage.

C. Store equipment and materials in secure and dry storage facility.

PART 2 – PRODUCTS

2.01 EQUIPMENT AND MATERIALS

A. Grounding and Bonding Equipment, Components and Materials: Conform to UL 467, IEEE 837 and the additional requirements specified herein.

B. Ground Rods: Medium carbon steel core, copper-clad by the molten weld casting process, size of 1”x10’- 0” (one inch in diameter by ten feet in length) long or as indicated, UL listed.

C. Bare Conductors: ASTM B3, Class B stranded, annealed copper conductor, unless otherwise indicated, size as indicated.

D. Bus Bar: ASTM B187, 98 percent conductivity copper, size as indicated.

E. Standoff Insulators (for bus bars): UL rated and constructed from flame retardant, glass reinforced thermoset polyester compound with a current carrying capacity for the intended application in accordance with ASTM D495.

F. Single Conductor Insulated Wire: Refer to Section 26 05 24, Low Voltage Wires and Cables. Use insulated ground wire for grounding communication and train control systems.

G. Terminal Lugs: Refer to Section 34 21 50, Common Materials and Methods for Traction Power.

H. Jumpers: Tin plated copper, braided, flexible jumper.

I. Bolts and miscellaneous hardware for grounding: Material shall be silicon bronze.

J. Ground rod clamps: Corrosion resistant silicon bronze clamps with screws.

K. Universal perimeter gate/fence pipe clamps: Highly conductive thinned copper with feature stainless steel hardware

L. Cable Connectors (for enclosures without ground lugs): Highly conductive copper alloy.

M. Oxide inhibiting compound: Non-melting, non-petroleum base material with suspended zinc particles and suitable for application on the intended materials.

N. Cold galvanizing compound: Corrosion protective zinc coating compliant to ASTM A780.

O. Safety ground wire mesh: Prefabricated wire mesh, solid copper wire size is No. 6 AWG. All joints of the prefabricated wire mesh shall be silver brazed at the wire crossing points.

P. Fiberglass reinforced thermoset polyester molded material: NEMA GP0-3, minimum 1/2 inch in thickness, in red. The sizes shall be as indicated.

2.02 EXOTHERMIC WELDING PROCESS

A. Exothermic welding process shall consist of a system of standard manufactured molds for each type of weld to be made and powdered metals that are placed in the mold along with the conductors to be welded. Weld metals shall be of types designed for the types of metals being joined. Ignition of the powder shall produce molten copper, which welds the conductors to each other and to a surface, as the case may be. Exothermic materials and products shall be “CADWELD” manufactured by ERICO Products, Inc, Thermoweld, or equal.

B. Compression or mechanical type grounding connections are not equal to exothermic welded connections for applications in concealed, underground, wet or damp location, and are not permitted.

2.03 COAL TAR EPOXY COATING

A. Coal tar epoxy shall be used as a protective coating over exothermic welds, if recommended by the weld manufacturer.

B. Coating shall be polyamide cured coal tar epoxy, applied to 15 mils dry film thickness.

C. Approved Manufacturers:

1. Carboline Company, Dampney Company, Inc., Tnemec Coating Company, or equal.

D. Coal tar epoxy coating products shall have the following minimum properties:

1. Minimum volume resistivity of 1010 ohm-centimeters.

2. Thickness as recommended by the manufacturer for the specified system but not less than 15 mils.

3. Provide a chemical or mechanical bond to the metal. Pressure sensitive or non-bonding systems are not acceptable.

4. Mechanical characteristics capable of withstanding reasonable abuse during handling and installation and earth stresses after installation for the design life of the system.

2.04 GROUND WELL BOXES

A. Precast, high density, reinforced concrete with full traffic covers. All covers shall be slip resistant and marked “GROUND WELL”.

B. Minimum size of 12-inch diameter by 24-inch depth.

C. Manufacturer: Christy, Brooks Products, or equal.

PART 3 – EXECUTION

3.01 REQUIRED GROUNDING SYSTEM PARAMETERS

A. At high voltage substations, the ground resistance from equipment or structure to ground well shall not exceed **one Ohm (1 Ω)**.

B. At Traction Power substations, the ground resistance from ground test station to earth shall not exceed two Ohms **(2 Ω)**.

C. For any other systems the total ground resistance shall not exceed **five Ohms (5 Ω)**.

D. Provide ground grid conforming to IEEE 80 step and touch potential criteria. Grounding calculations shall consider a 50-kg person and 0.5 second fault clearing time for step and touch potential calculations.

3.02 INSTALLATION OF GROUNDING SYSTEM

A. General:

1. Provide continuous ground/bond conductor or splice using ground/bond connections made in accordance with IEEE 81, IEEE 837, NEC, CEC, and the manufacturer’s recommendations.

2. Connect substation grounding grid as indicated on the Contract Drawings.

3. Provide separate systems and equipment grounding as indicated.

4. Ground metallic conduits, raceways, under-floor ducts, cable trays, boxes, cabinets, exposed expansion joints, lighting fixtures, and receptacles in accordance with the California Electrical Code.

5. Safety ground wire mesh: Install solid copper wire mesh in accordance with the manufacturer’s requirements.

6. Mechanical digging apparatus shall not be used within two feet of any existing underground utility. If existing underground utilities are found during installation of grounding grid system, Contractor shall hand dig all excavations within two feet of the existing underground utility. Bring any existing underground utility unexpectedly encountered to the attention of the Engineer or the Inspector.

B. Ground Connections:

1. All medium voltage equipment shall be bonded through to the ground grid by a minimum of two bonding conductors.

2. All connections shall be made in accordance with the manufacturer's requirements. All connections shall be cleaned and coated with a bitumastic epoxy before backfilling.

C. Grounding conductors shall be protected from physical and environmental damage. Wherever possible, grounding and bonding conductors routed in rooms shall be enclosed in a non-metallic raceway. Exposed conductors, which shall extend from a concrete surface, shall be located as close as possible to a corner. Where conductors are required to run exposed, as in the connection to the main ground bus, grounding conductors shall be supported by corrosion resistant metallic hardware at 4-foot intervals or less.

D. Completely remove all paint, dirt, or other surface coverings at grounding conductor connection points so that good metal-to-metal contact is made. Make connections with clean, bare metal at points of contact.

E. Service grounds and grounding or bonding of electrical service equipment shall be with continuous un-spliced grounding conductor.

F. Unless advised to the contrary protect in place the existing ground grids. Repair damage to the existing ground grids at no additional cost to the District.

G. Protect the exposed ground grid, ground rods, ground conductors, or ground connections from damage and/or theft. Replace damaged and/or lost materials at no additional costs to the District.

H. Do not route ground conductors and/or place ground rods directly under structures.

I. Provide exothermic welds for buried or embedded connections. Unless otherwise specified all connections located outdoors, or above ground in damp, or wet locations shall be by exothermic welding. Exothermically weld connections to ground rods. Compression or mechanical connections shall not be used underground. Grounding connections shall not be soldered. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.

1. Test all welds by striking with a two-pound steel hammer. Replace all defective, damaged, or loose welds.

2. Test welds for electrical resistance. The completed exothermic weld shall have a resistance equal to or less than a length of cable equal to the length of weld, and the current carrying capacity of the weld shall be equal to or greater than the cable itself. Document electrical resistance.

J. Compatibility

1. Make connections so galvanic action or electrolysis possibility is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.

2. Use electroplated or hot-thin-coated materials to ensure high conductivity and to make contact points closer to order of galvanic series.

K. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.

L. Make aluminum-to-galvanized steel connections with tin-plated copper jumpers and mechanical clamps.

M. Coat and seal connections having dissimilar metal with inert material to prevent future penetration of moisture to contact surfaces.

N. Oxide inhibiting compound shall be used for all mechanical connections where copper to aluminum or copper to steel connections are made. The compound shall be applied to all copper, aluminum, and steel parts. In addition, all aluminum contact surfaces shall be abraded after application of the inhibiting compound, and before attachment of the bolted connection.

O. Use hydraulic compression tools to provide correct circumferential pressure for compression-type connections. Use tools and dies recommended by connector manufacturer. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on grounding conductor.

P. Lugs

1. Two-hole compression type terminal lugs shall be used to connect grounding conductors to equipment enclosures and ground test stations.

2. For No. 8 AWG and larger, use pressure-type grounding lugs. No 10 AWG and smaller ground conductors may be terminated with winged pressure-type connectors.

Q. All splice connections shall be made in accordance with the manufacturer’s requirements.

R. If insulated grounding conductors are connected to ground rods or ground test stations, insulate entire area of connection and seal against moisture penetration of insulation and cable.

S. Connect ground test stations/bus bars to ground system within the traction power facilities. Provide water stops on ground cable risers where the risers enter the structure.

T. Post backfilling paint exposed bare copper conductors and ground rods ANSI Z55.1; Type 61 light gray.

3.03 GROUND RODS

A. Bury ground rods vertically with rod top a minimum of 2’-0” below grade or with rod top terminated in a gravel filled ground well. If extensive rock formation is encountered, relocate ground rods to a new location as approved by the Engineer.

B. Interconnect ground rods longitudinally and laterally with minimum 250 kCMIL stranded bare copper wire or as indicated.

C. Ground the non-current-carrying metal enclosures with a conductor sized as required by the NEC, CEC.

D. Connect the grounding conductor to each rod using exothermic welds. In the case of confined spaces (i.e. underground structures) clamp connectors are acceptable to ensure compliance to CalOSHA requirements.

E. Install supplemental ground rods or other appurtenances to make the grounding system conform to the specified minimum ground resistance requirements.

3.04 GROUND WELL BOXES

A. Install ground well boxes as indicated in the Contract Drawings.

B. Install ground rods with ends four inches above a sand backfill with approved exothermic welded connections of grounding conductors fully visible and accessible.

3.05 GROUND TEST STATIONS / BUS BARS

A. Install ground test station 2’-0” above finished floor and/or finished grade.

B. Identify each terminated ground conductor (with the associated originating equipment designation) at each ground test station.

3.06 GROUNDING CONDUCTORS/WIRES

A. Conductor Types:

1. Equipment/Raceway Grounding Conductors: - Insulated with green-colored insulation.

2. Grounding Electrode Conductors: Stranded cable.

3. Underground conductors: Bare, stranded cable.

B. All grounding wires shall be sized in accordance with the NEC, CEC, and the manufacturer’s recommendations to provide adequate conduction path for all possible faults and electrical interference currents.

C. Route ground conductors/wires along shortest and straightest paths possible, unless specified otherwise. Avoid obstructing access or placing conductors/wires where they may be subjected to strain, impact, or damage.

D. Bury ground conductors vertically with a minimum of 3’-0” below grade. If site conditions prevent compliance to this requirement request clarification from the Engineer.

3.07 BONDING STRAPS AND JUMPERS

A. Install bonding straps and jumpers so vibration by equipment mounted on vibration isolation hangers or supports is not transmitted to rigidly mounted equipment.

B. Use exothermic-welded connectors for outdoor locations, unless a disconnect type connection is required, then use a bolted clamp.

C. Bond straps directly to the structure taking care not to penetrate any adjacent parts.

D. Install straps only in locations accessible for maintenance.

3.08 GROUNDING CONNECTIONS TO NON-CURRENT CARRYING CONDUCTIVE ENTITIES

A. Ground the non-current-carrying metal enclosures with a conductor sized as required by the NEC, CEC.

B. Reinforcement Steel

1. Exothermically welded, embedded ground cables and fittings to concrete reinforcing steel shall be secured with steel tie wires to prevent displacement during concrete placement.

2. Electrically bond all reinforcement steel associated with cast in place structures to the traction power facility ground grid.

C. Ground fencing and other metallic frame structures as follows:

1. Ground metal fencing and gates to one-inch diameter by ten feet long ground rods, buried three feet outside fenced area, using ground cable sized minimum 2/0 and clamps as indicated in the Contract Drawings. Fence grounding shall be independent of the traction power facility ground grid.

2. Install braided flexible jumper at open fence joints and gates for continuity to ground.

3. Ground other metallic frames of non-current carrying structure to main station ground grid, using minimum No. 6 bare copper wire.

3.09 LIGHT FIXTURE GROUNDING

A. Unless otherwise specified, provide the housing of each ballasted lighting fixture with a separate, factory-installed grounding device.

B. A separate grounding conductor shall be attached to the grounding device on each fixture housing and connected to the ground lug terminal in the hand hole of the light pole.

C. Fluorescent fixtures connected end-to-end shall have a common ground conductor between them to provide a continuous ground path.

D. Light poles shall be grounded by use of a separate grounding conductor connected at one end to the grounding lug in the hand hole of each pole, and the other end connected to either the steel rebar of the pole foundation or directly to the ground grid.

3.10 RACEWAY GROUNDING

A. All metallic raceway systems shall be bonded together to provide a continuous electrical ground path. Metallic raceways shall be bonded to other raceway components using insulated grounding bushings. Grounding bushings shall be connected to the grounding system using conductors sized in compliance with NEC, CEC, and as specified on the Contract drawings.

B. Metallic conduits shall be electrically and mechanically continuous and connected by bonding to the grounding system.

C. If metallic raceways terminate at metal enclosures without mechanical and electrical connection to the enclosure, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to ground bus or terminal in the enclosure. Bond electrically non-continuous conduits at entrances and exits with grounding bushings and bare grounding conductors, unless specified otherwise.

D. Ground conductors shall be provided in non-metallic raceway systems (unless they are designated for telephone and data cables) in accordance with the NEC and CEC.

E. Install separate ground conductor across flexible connections.

F. Metallic conduit containing only grounding or bonding conductor, and which is provided for mechanical protection of the conductor, shall be bonded to that conductor at the entrance and exit from the conduit.

G. Install all ground bushings and incidentals.

H. Provide liquid-tight flexible metallic conduits with a continuous copper bonding conductor spiral wound between convolutions, as required by the NEC and CEC.

I. Mounting hardware, associated with non-current-carrying conductive boxes, conduits, and cable tray systems in which dc cables are routed, shall be electrically isolated from the building and/or structure.

J. Metallic Cable Trays

1. Metallic cable trays shall be electrically and mechanically continuous.

2. Install bonding jumpers at all cable tray connections.

3. Connect each isolated metallic cable tray system or the entire cable tray system to the building grounding systems with a bare copper conductor in accordance with the NEC, CEC, and NEMA VE 1 and VE 2.

4. Base size determination of ground cable on the largest power and control conductor in the cable tray and to withstand the maximum short circuit current:

   a. Minimum Size: - 14 AWG.

   b. Maximum Size: - 750 kcmil.

3.11 UNDERGROUND DUCTBANKS AND STRUCTURES

A. Provide at least one driven ground rod at each underground structure. Set the ground rod depth with four inches exposed above the finished floor. Seal floor opening with waterproof, nonshrink grout.

B. All non-current carrying conductive parts within underground structures shall be grounded. Train conductors level or plumb around corners and fasten to the walls of the underground structure. Size the ground conductor in accordance with the NEC and CEC, but shall be at least No. 6 AWG.

3.12 ELECTRICAL SERVICE SYSTEM GROUNDING

A. Grounding and bonding for the electrical service shall be provided in accordance with the electric utility service provider’s requirements.

B. The electric utility service provider’s ground loop shall be isolated, insulated, and physically separated from the AC system ground mats, if physically possible.

C. Grounding and bonding for pad mounted transformers shall be provided in accordance with the electric utility service provider’s requirements.

3.13 BONDING AND GROUNDING OF COMMUNICATIONS EQUIPMENT RACKS, CABINETS AND ENCLOSURES (E.G. CO3, CO4)

A. Ground and bond racks, cabinets, and enclosures per the manufacturer’s recommendations, NECA 607 and the Contract drawings.

3.14 FIELD ENGINEERING, QUALITY CONTROL AND TESTS

A. Field engineering, quality control and testing shall be performed in accordance with the requirements of the following:

1. Section 01 43 00, Quality Assurance.
2. Section 01 45 00, Quality Control.
3. Section 01 71 23, Field Engineering.
4. Section 34 21 80, Traction Power System Field Acceptance Testing.

B. General

1. The existing ground grids shall remain.
2. Submit field test, plans, procedures and pre-printed test data sheets in accordance with Section 34 21 80, Traction Power System Field Acceptance Testing.
3. Furnish equipment for testing the grounding and bonding system after installation, including service test kit.
4. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not available, use those specified in UL 486 A&B or NECA recommendations.
5. Confirm that the installed grounding and bonding system is in conformance with the approved drawings.
6. Inspect for physical damage, and tightness of connections, defective wiring, and general mechanical and electrical conditions.
7. All non-conforming work shall be reworked by the Contractor at no additional cost to the District.

3.15 FIELD QUALITY CONTROL

A. Ground Resistance:

Test the grounding system by the three-point fall of potential method under the observation of the Engineer. Ground resistance measurement test shall be made in normally dry conditions not less than 48 hours after the last rainfall. If the test is influenced by nearby ground grid, then the test shall be repeated by locating reference electrode to a longer distance until interference is minimized.

1. Each ground rod shall be tested individually before connecting them together to make grid. Resistance of each ground rod shall be tested to verify it is 25 ohms or less.

2. Testing shall verify that ground grid resistance corresponds to the grounding grid calculation.

    a. Do not place backfill, install subgrade, or pour concrete above ground grid, ground rod, ground conductors, or ground connections until inspection by the Engineer is completed, testing of the grounding system is complete, and the grounding installations are approved.

    b. Do not exothermically weld the ground grid system to the invert slab rebars for the purpose of meeting the ground resistance requirement criteria.

B. Ground System Continuity: Test equipment enclosures, conduit, raceways, exposed expansion joints, lighting fixtures, receptacles, light standards, steel stairs, handrails and non-current carrying conductive entities for continuity to the ground system.

1. Test the electrical resistance of each exothermic welded connection in accordance with Art. 3.03 I of this Section.

2. Test all GFCI receptacles and circuit breakers for proper connection and operation with methods and instruments prescribed by the manufacturer.

C. Test Reports

1. Submit to the Engineer a certified written record of inspections, test, and detailed test results in the form of a test log, on the satisfactory completion of tests. All equipment and other components at which tests have been satisfactorily completed shall be tagged to indicate completion of testing.

3.16 CLEANING

A. Refer to Section 01 74 14, Cleaning, for additional requirements.

B. Remove all waste material from the Jobsite(s) at no additional cost to the District.

3.17 DEMONSTRATION AND TRAINING

A. Refer to Section 01 79 00, Demonstration and Training, for additional requirements.

3.18 CLOSEOUT PROCEDURES

A. Refer to Section 01 77 00, Closeout Procedures, and Section 01 78 39, Contract Record Documents, for additional requirements.

END OF SECTION 34 21 60

SECTION 34 21 70

TRACTION POWER FACILITIES INSTALLATION REQUIREMENTS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Traction Power Equipment.

B. Underground Ductbanks.

C. Precast Structures and Covers.

D. Cast-In-Place Structures.

E. Cable Trench Covers and Gratings.

F. Grounding and Bonding.

G. Storm Water, Sewage and Water Lines.

H. Site Finish.

I. Perimeter Security Barrier.

J. Gates.

K. Exterior Light Fixtures.

L. Blue Light Stations.

M. Communications Equipment.

N. Sump Pumps and Associated Controllers.

O. Failsafe to Close Drain Valve with Oil Detection Materials.

P. Wiring Devices.

Q. Static Signage.

R. Conduit, Cable Trays and Boxes.

S. Cables and Wires.

T. Cable Splice and Termination.

U. Identification

V. Fire Proofing/Barriers

1.02 RELATED SECTIONS

A. Refer to the following Sections for requirements relating to inspection and testing activities:

1.	Section 01 11 00	Summary of Work
2.	Section 01 33 00	Submittal Procedures
3.	Section 01 33 23	Shop Drawings, Product Data, and Samples
4.	Section 01 35 14	Operating System Interface
5.	Section 01 43 00	Quality Assurance
6.	Section 01 45 00	Quality Control
7.	Section 01 60 00	Product Requirements
8.	Section 01 71 13	Mobilization
9.	Section 01 74 14	Cleaning
10.	Section 01 77 00	Closeout Procedures
11.	Section 01 78 39	Project Record Documents
12.	Section 03 05 15	Portland Cement Concrete
13.	Section 03 11 00	Concrete Forming
14.	Section 03 20 00	Concrete Reinforcing
15.	Section 03 30 00	Cast-In-Place Concrete
16.	Section 04 22 00	Concrete Unit Masonry
17.	Section 05 50 00	Metal Fabrications
18.	Section 07 84 00	Firestopping
19.	Section 20 50 13	Raceways for Facility Services
20.	Section 20 50 16	Underground Ductwork and Structures for Facility Services
21.	Section 20 70 26	Common Materials and Methods for Electrical Systems
22.	Section 22 11 01	Water Distribution
23.	Section 22 13 01	Sanitary Sewerage

24.	Section 22 14 01	Storm Drainage
25.	Section 22 14 29	Sump Pumps
26.	Section 26 05 24	Low Voltage Wires and Cables
27.	Section 26 50 00	Lighting
28.	Section 27 13 01	Communication Cables and Related Equipment
29.	Section 28 10 01	Access Control Systems
30.	Section 28 41 29	Closed Circuit Television System
31.	Section 31 23 19	Dewatering
32.	Section 32 11 24	Aggregate Drainage Layer
33.	Section 32 31 13	Chain Link Fences and Gates
34.	Section 33 05 16	Utility Structures
35.	Section 33 05 28	Trenching and Backfilling for Utilities
36.	Section 33 11 00	Water Utility Distribution Piping
37.	Section 33 31 00	Sanitary Utility Sewerage Piping
38.	Section 33 40 00	Storm Drainage Utilities
39.	Section 33 46 00	Subdrainage
40.	Section 34 21 01	General Requirements for the Traction Power System
41.	Section 34 21 05	Prefabricated AC and DC Equipment Houses
42.	Section 34 21 50	Common Materials and Methods for Traction Power
43.	Section 34 21 60	Grounding and Bonding for Traction Power Facilities
44.	Section 34 21 80	Traction Power System Field Acceptance Testing
45.	Section 34 22 23	Traction Power Cables

1.03 MEASUREMENT AND PAYMENT

A. Separate measurement and payment shall not be made for work required under this Contract Specifications Section. All costs connected with the work specified herein shall be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work.

1.04 REFERENCES

A. All installation activities shall be in accordance with the latest edition of the following codes, standards, and specifications except as provided otherwise herein. Where requirements conflict with requirements specified herein or elsewhere in the Contract, the more restrictive requirements shall apply.

B. American National Standard Institute (ANSI)

1. ANSI/IEEE C2 National Electrical Safety Code

C. California Building Electrical Code (CBC)

D. California Code of Regulations (CCR)

Title 8	Industrial Relations, Division 1, Chapter 4, Subchapter 4, Construction Safety Orders.
Title 8	Industrial Relations, Division 1, Chapter 4, Subchapter 5, Electrical Safety Orders.
Title 19	Public Safety, State Fire Marshal.
Title 24	Part 3, California Electrical Code

E. CalOSHA – Electrical Safety Orders

F. Electronics Industry Association (EIA) 568-B Commercial Building Telecommunications Cabling Standard

G. International Electrical Testing Association (NETA)

NETA ATS	Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

H. National Fire Protection Agency (NFPA):

NFPA 70	National Electrical Code
NFPA 70B	Recommended Practice for Electric Equipment Maintenance
NFPA 70E	Standard for Electrical Safety in the Workplace

NFPA 101	Life Safety Code
NFPA 110	Emergency and Standby Power Systems
ANSI/NFPA 130	Standard for Fixed Guideway Transit and Passenger Rail Systems
NFPA 780	Installation of Lightning Protection Systems

I. National Fire Protection Agency (NFPA):

1.	NFPA 70	National Electrical Code
2.	NFPA 70B	Recommended Practice for Electric Equipment Maintenance
3.	NFPA 70E	Standard for Electrical Safety in the Workplace
4.	NFPA 101	Life Safety Code
5.	NFPA 110	Emergency and Standby Power Systems
6.	ANSI/NFPA 130	Standard for Fixed Guideway Transit and Passenger Rail Systems
7.	NFPA 780	Installation of Lightning Protection Systems

J. Telecommunications / Electronics Industry Association (TIA / EIA) 606-A, Administration Standard for Commercial Telecommunications Infrastructure

K. Underwriters Laboratories Inc. (UL)

1.	UL 486A-486B	Standard for Safety Wire Connectors

1.05 SUBMITTALS

A. Refer to the following Sections for additional requirements:

1.	Section 01 33 00,	Submittal Procedures
2.	Section 01 33 23,	Shop Drawings, Product Data and Samples

B. Submit following documents for equipment and materials specified herein and provided under the Contract for the traction power facilities:

1. Type Test Certificates (Cables).
2. Material safety data sheets.
3. Product data sheets.

4. Procedures and methods for shipping, handling, unloading, and storage.

5. Installation manual & drawings:

    a. Installation manual shall include the following:

        1) A table of contents that shall identify all pages of the manual by revision and date.

        2) A list of all the applicable sections of electrical codes, and of National and Industry Standards applicable to the installation.

        3) All the installation practices and procedures that the Contractor plans to use to accomplish the installation of the traction power system. This shall be kept current at all times.

        4) A list of all installation drawings by number, revision, title and approval status and a copy of each drawing reduced to B size (11 by 17 inches).

        5) All District-approved typical and standard drawings reduced to B size (11 by 17 inches).

        6) All quality control procedures associated with the construction of the traction power facilities.

        7) All installation verification procedures and data sheets.

        8) Staging and implementation plans.

    b. Installation drawings shall include the following:

        1) Mounting details.

        2) List of items to be installed.

        3) Locating dimensions and associated tolerances.

        4) Detailed bill-of-materials.

        5) Special installation or process requirements.

6. Rigging Plan

    a. Rigging plan shall include the following:

        1) Plan view showing locations of cranes, operating radii, with delivery or disposal locations shown.

        2) Crane rating sheets showing cranes to be adequate for the lift. Crane and boom nomenclature is to be indicated.

        3) Plans and computations showing weight of pick.

        4) Location plan showing obstructions, indicating that the proposed swing is possible. Location plan shall also show locations of manholes, underground duct banks and other utilities and infrastructure that could be damaged by crane and support vehicle positioning (vehicle body, wheels, and outriggers). Show location and

type of cribbing and other materials proposed to prevent damage to this infrastructure.

5) Data sheet listing type and size of slings or other connecting equipment. Include copies of catalog or information sheets of specialized equipment. Detail method of attachment on erection plan.

6) A complete procedure is to be included, indicating the order of lifts and any repositioning or re-hitching of the crane or cranes.

7) Temporary support of any components or intermediate stages is to be shown.

8) A time schedule of the various stages must be shown, as well as a schedule for the entire lifting procedure.

7. Survey verification records for AC and DC equipment houses and equipment pad foundation installation tolerances.

8. Product data for outdoor lighting for the traction power facilities.

9. Product data for the Intrusion detection and surveillance system at traction power facilities.

10. Cable pull calculations for cables running between AC and DC equipment houses, and between AC and DC equipment houses and points external to traction power facility sites. Calculation shall demonstrate that pull tensions and sidewall pressures are within acceptable tolerances. No cable pulls shall be undertaken prior to acceptance of cable pulling tensions by the District.

11. Building and equipment anchoring calculations showing anchoring meets seismic requirements. A California professional structural engineer shall approve calculations. Seismic design calculations used shall meet seismic design requirements of the latest California Building Code (CBC) requirements and shall use an Importance Factor (Ip) = 1.5.

12. Weekly issue tracking logs shall be submitted as part of the progress report to the Engineer.

1.06 QUALITY ASSURANCE AND SUPPLIER QUALIFICATIONS

A. Refer to Section 01 43 00, Quality Assurance, and Section 01 45 00, Quality Control, for quality assurance, quality control and qualification requirements.

B. Electrical components, devices, and accessories shall be listed and labeled in conformance with NFPA 70, Article 100. Electrical components, devices, and accessories shall comply with NECA 1, Standard for Good Workmanship in Electrical Construction.

C. Contract drawings shall indicate preliminary dimensions for equipment, including clearances between equipment and for adjacent surfaces and other items. Deviations to indicated or noted dimensions shall be submitted to the District for review and approval.

D. The manufacturer of the equipment and cables shall have a minimum of 5 years of successful and proven transit, industrial, or utility experience of providing equipment and cables similar to those furnished under the Contract.

E. Equipment, devices, components, cabling, materials, and appurtenances shall be proven standard products, or equivalent to the standard products of manufacturers engaged in the production of such entities for at least the past 5 years.

F. All equipment, devices, components, cabling, materials, and appurtenances shall be new, unused in any other application, and shall possess properties and characteristics in accordance with the applicable industry standards.

G. All equipment, including parts and devices, shall be new, the manufacturer's latest standard designs that conform to the Contract, and free from defects in material and workmanship.

H. The construction of all equipment, devices, components, cabling, materials, and appurtenances shall comply, as applicable to the requirements specified in NFPA 130.

I. Installation Activities

1. All installation activities associated with the traction power facilities shall be performed by a State of California licensed Contractor in accordance with state law. The Contractor shall be skilled and experienced in the installation of the products specified in the Contract.

2. Unlicensed, unskilled, and inexperienced workers shall not be permitted to install equipment, devices, components, cabling, materials, and appurtenances in the field, or perform work of any kind on the Contract.

J. The Contractor and Contractor's subcontractor(s) shall show evidence of the following to be considered Bidder:

1. Three (3) years minimum experience and three successful projects installing, testing, and commissioning 34.5 kV medium voltage power equipment requiring busway and circuit breakers during the past seven (7) years.

2. Three (3) years minimum experience and three successful projects installing, testing, and commissioning 34.5 kV medium voltage power cables during the past seven (7) years. Experience shall include installation of elbow connectors and outdoor cable terminations.

3. Three (3) years minimum experience and three successful projects installing Class A super-flat concrete surfaces during the past seven (7) years.

4. Evidence of the above experience shall include references with current email addresses and current telephone numbers for each project cited as evidence of experience.

1.07 DELIVERY, STORAGE AND HANDLING

A. Refer to Section 01 60 00, Product Requirements, for general delivery, storage, and handling requirements.

B. Securely wrap, package, and label each unit for safe handling during shipment. Suitable crating, blocking, and supports shall be provided so equipment and materials will withstand expected domestic shipping and handling shocks and vibration. Clearly label temporary internal bracing of equipment as “Temporary Bracing: To Be Removed Before Operations”.

C. Provide to the District as an option to the base scope of work a secure storage facility (of at least 100,000 square feet) located within 10 miles of the jobsite for a period not least than 1 year to house equipment, pre-engineered houses and cables.

D. All equipment, cabling, conduit and cable tray, ductbanks, materials, and appurtenances shall be protected and maintained in new condition throughout the Contract period until final acceptance by the District.

E. All equipment, cabling, conduit and cable tray, materials, and appurtenances intended for use on the Contract shall be shipped and stored in accordance with the manufacturer’s recommendations such that damage, distortion or reduction in life is prevented.

F. All stored equipment, conduit and cable tray, materials, and appurtenances subject to corrosion shall be protected by weatherproof covers or coatings, and off the floor or ground.

G. Insulated cable ends shall be sealed and stored in a dry location to prevent the entry of moisture into the cable conductors.

H. All equipment shall be stored with all ports, covers, and all other enclosure openings closed to prevent ingestion of dirt or moisture, and kept dry and free from condensation.

I. All loose shipped traction power facility components shall include parts and assembly instructions within each package for the components therein.

J. Special care shall be taken with the storage of electrical equipment prior to installation.

K. All materials with a defined life expectancy shall be clearly marked with expiration date and shall not be used beyond the expiration date.

L. All electrical equipment, cabling, conduit and cable tray, materials, and appurtenances with special handling or storage requirements shall be handled or stored according to the manufacturer’s requirements.

M. All equipment, cabling, conduit and cable tray, materials, and appurtenances shall be clearly marked and stored with appropriate nomenclature to prevent misapplication.

N. Concealed damage shall be inspected and reported to carrier within their required time period.

O. Rejected or unused equipment, cabling, conduit and cable tray, materials, and appurtenances, or entities, which are not in conformance with the Contract requirements, shall be so marked and promptly removed from the Jobsite.

1.08 GENERAL REQUIREMENTS FOR THE TRACTION POWER SYSTEM

A. Refer to Section 34 21 01, General Requirements for the Traction Power System, for requirements.

PART 2 – PRODUCTS

2.01 UNDERGROUND DUCTBANKS

A. Refer to Section 20 50 16, Underground Ductwork and Structures for Facility Services, for the product requirements relating to reinforcement steel, conduits, spacers, ductbank tie-downs, sand, cast-in-place concrete, yellow warning tape, conduit mandrels and brushes, and pull lines.

2.02 PRECAST STRUCTURES & COVERS

A. A. Refer to Section 20 50 16, Underground Ductwork and Structures for Facility Services, and Section 33 05 16, Utility Structures, for the product requirements relating to pre-cast concrete electrical boxes, pullboxes, ground rod boxes, manholes, handholes, and vaults; covers and frames; gratings; ladders; sumps, inserts; damp proofing, and hardware.

2.03 CAST IN PLACE STRUCTURES

A. Refer to Section 03 05 15, Portland Cement Concrete, Section 03 11 00, Concrete Forming, Section 03 20 00, Concrete Reinforcing, and Section 03 30 00, Cast-In-Place Concrete, for the product requirements relating to Portland cement concrete, concrete forming, and reinforcement steel.

2.04 CABLE TRENCH COVERS & GRATINGS

A. Refer to Section 05 50 00, Metal Fabrications, and Section 33 05 16, Utility Structures, for the product requirements relating to cable trench covers, gratings, and associated vehicle loading.

2.05 GROUNDING AND BONDING

A. Refer to Section 34 21 60, Grounding and Bonding for Traction Power Facilities for the product requirements relating to ground well boxes, ground rods, bare and insulated conductors, ground test stations, jumpers, termination hardware / connectors, exothermic welds, and coatings.

2.06 STORM WATER, SEWAGE AND WATER LINES

A. Refer to the following Sections for product data:

1. Storm Drainage (Mechanical): Section 22 14 01, Storm Drainage
2. Storm Drainage (Civil): Section 33 40 00, Storm Drainage Utilities.
3. Sanitary Sewerage (Mechanical): Section 22 13 01, Sanitary Sewerage.
4. Sanitary Sewerage (Civil): Section 33 31 00, Sanitary Utility Sewerage Piping.
5. Water Distribution (Mechanical): Section 22 11 01, Water Distribution.
6. Water Distribution (Civil): Section 33 11 00, Water Utility Distribution Piping.

2.07 SITE FINISH

A. Refer to the Contract drawings and applicable sections for requirements.

2.08 PERIMETER SECURITY BARRIER

A. Refer to Section 03 30 00, Cast-In-Place Concrete, Section 04 22 00, Concrete Unit Masonry, and Section 32 31 13, Chain Link Fences and Gates, for the product requirements relating to concrete masonry units, cement, reinforcement steel, precast beams, lintels and copings, mortar, grout, surface sealant, fence fabric, pipe framework, tension wire, post caps and fittings, truss rods, stretcher bars, accessories, barbed wire extension arms, gates, and pipe sleeves.

2.09 GATES

A. Refer to Section 05 50 00, Metal Fabrications, and Section 32 31 13, Chain Link Fences and Gates, for the product requirements relating to steel materials, anchors, accessories, galvanization, gate frames, fabrication, and hardware.

2.10 EXTERIOR LIGHT FIXTURES

A. Refer to Section 26 50 00, Lighting, for the product requirements relating to light fixtures, fixture mounting hardware, and lighting control equipment (as applicable).

2.11 BLUE LIGHT STATIONS

A. Refer to Section 26 50 00, Lighting, for the product requirements relating to blue light stations.

2.12 COMMUNICATIONS EQUIPMENT

A. Refer to Section 28 10 01, Access Control Systems, and Section 28 41 29, Closed Circuit Television System, for installation requirements relating to smart card readers and covers; request to exit detectors; key-in-lever cylindrical locksets; energy transfer hinges; door contacts; access control panels; fixed and PTZ cameras; camera housings; camera mountings, and PTZ camera power supply panels. Refer to Section 33 83 01, Radio Network/Trunked Radio System for requirements related to installation of radio systems within traction power facilities.

2.13 SUMP PUMPS AND ASSOCIATED CONTROLLERS

A. Refer to Section 22 14 29, Sump Pumps, for the product requirements relating to sump pumps, motors, controls, guide rails and lifting cables, and hoists.

2.14 FAILSAFE TO CLOSE DRAIN VALVE WITH OIL DETECTION MATERIALS

A. A failsafe shall be provided to close drain value consisting of, the following:

1. Filter cage and filters.

2. Ball valve.

3. Pipe and fittings.

4. Mounting hardware and appurtenances.

B. SPI, Inc. or equal

2.15 WIRING DEVICES

A. Refer to Section 20 70 26, Common Materials and Methods for Electrical Systems, and Section 34 21 50, Common Materials and Methods for Traction Power, for the product requirements relating to toggle switches, commercial grade occupancy sensors, convenience-outlet receptacles, GFCI receptacles, and cover plates.

2.16 STATIC SIGNAGE

A. Refer to Contract Drawings and Sections for product requirements and detailing.

2.17 CONDUIT, CABLE TRAY AND BOXES

A. Refer to Section 20 50 13, Raceways for Facility Services, Section 26 05 29, Hangers, Supports and Seismic Protection, Section 26 05 53, Identification Requirements and Section 34 21 50, Common Materials and Methods for Traction Power, for the product requirements relating to enclosures and boxes; conduit and fittings; conduit mandrels and brushes; cable tray and fittings; mounting hardware, inserts and seismic bracing; coating and compounds; and pull cords.

B. Cable trays shall be sized (within cable trenches) to permit MV cables to be installed in single layer.

C. Boxes for fiber optic cables shall be sized to accommodate the fiber optic cable manufacturer's requirements and the NEC/CEC.

2.18 CABLES AND WIRES

A. Unless otherwise specified cables shall:

1. Be low smoke, zero halogen properties that shall not support combustion.

2. Pass the flame propagating criteria of IEEE 383 and shall have a minimum circuit time of 5 minutes in the flame test of IEEE 383. Provide test certificate with every shipment of cables.

3. Comply with requirements specified in NFPA 130 Standard for Fixed Guideway Transit and Passenger Rail Systems.

B. Refer to Section 26 05 24, Low Voltage Wires and Cables, and Section 34 21 50, Common Materials and Methods for Traction Power, for the product requirements relating to wire and cable markings and color coding, fixture wires, bare conductors, 50 V control circuit wires, cable supports and fasteners, and conductor bundling straps.

C. Multiple Conductor LV Power, LV Control and Indication Cables shall meet the following criteria:

1. Conductor Material: ICEA stranded copper meeting requirements of ASTM B3, soft drawn.

2. Conform to NEMA WC70, approved for use in cable tray

3. Insulation Rating of 600 V

4. Multi-conductor cables shall be made by assembling individual or twisted pairs of insulated conductors into a tight cylindrical form using fillers that are compatible with other materials in the cable. The jacket used shall fit tightly to form a firm assembly.

5. Overall Covering: Cables shall be jacketed over the insulation.

6. Markings and color coding: Refer to Section 26 05 24, Low Voltage Wires and Cables.

7. Provide multiple conductor cable for all power applications, except receptacles when installed in cable tray for sizes up to 4/0 AWG.

8. Control and indication wires shall be minimum of 14 AWG stranded copper.

9. Size 14 AWG and Larger: NFPA 70, cross-linked-thermosetting-polyethylene insulated in accordance with NEMA WC 70.

D. Refer to Section 27 13 01, Communication Cables and Related Equipment, for the product requirements relating to fiber optic cables, fiber optic connectors and patch cords, category 6 cables and pigtail cables, emergency trip system cables, hardware, and connections.

E. Refer to Section 34 22 23, Traction Power Cables, for the product requirements relating to 35 kV and 2400 V cables.

2.19 CABLE SPLICE AND TERMINATION HARDWARE

A. Refer to Section 34 21 50, Common Materials and Methods for Traction Power, for the product requirements relating to LV cable splice and terminal connectors; and associated insulated materials.

B. Refer to Section 34 22 23, Traction Power Cables, for the product requirements relating to MV cable in-line, continuous splice kits, insulated splice kits, lugs, and fireproofing materials.

2.20 34.5 KV JUNCTION CUBICLES

A. Refer to Section 34 21 50, Common Materials and Methods for Traction Power for the product requirements relating to the cubicle design, construction, and components.

2.21 34.5 KV ISOLATION DISCONNECT SWITCHES

A. Refer to Section 34 21 56, 34.5 kV Isolation Disconnect Switches, for the product requirements relating to the isolation disconnect switches design, construction, and components.

2.22 MANUAL 1,500V DC DISCONNECT SWITCHES

A. Refer to Section 34 21 55, for the product requirements relating to enclosure, switch blade and contact surfaces, auxiliary contacts, cable terminations and connections, cable supports, gasketing, and nameplates.

2.23 IDENTIFIERS

A. Refer to Section 26 05 53, Identification Requirements for the identifier product requirements for component tags, equipment nameplates, conduit and cable trays, underground ductbanks, outlets, junction and pull boxes, wires cables, and fiber optic strands.

2.24 VOLTAGE MARKERS AND SAFETY SIGNAGE

A. Refer to Section 26 05 53, Identification Requirements, for the product requirements for voltage markers, warning labels, shock hazard and arc flash labels, safety, and instructional signs.

2.25 FIRE PROOFING/BARRIERS

A. Refer to Section 07 84 00, Firestopping, for the product requirements relating to fire stopping sealant, foam, and mineral fiber.

PART 3 – EXECUTION

3.01 GENERAL

A. Overview

1. Furnish and install the traction power facilities' civil infrastructure including earthwork, grading, foundations, pavement, landscaping, fencing, perimeter lighting as indicated.

2. Furnish and install equipment, conduit, underground ductbanks and structures, cable trays, cables in accordance with the National Electrical Installation Standards (NEIS) of the National Electrical Contractors Association (NECA).

3. Perform all electrical work in accordance with electrical work stages, phases and step schedule developed by the Contractor and approved by the District.

4. Perform and complete all work in a thorough, workmanlike manner, and shall follow the best modern practice in the installation of high-quality equipment and materials, notwithstanding omission of any requirement from the Contract.

5. Make and install all parts accurately to American standard gauges for ease of replacement and repairs. The Contractor shall furnish all special gauges and templates necessary for field erection. These shall become the property of the District at no extra cost.

6. Technical representative(s) from the traction power equipment supplier's organization shall be made available for supervision during installation of their equipment.

7. The information and requirements specified within the Contract do not make representations regarding the character or extent of the subsoils, water levels, existing structural, mechanical and electrical installations, above or below ground, or other sub-surface conditions which may be encountered during the work. Evaluate existing conditions based on examination of the Jobsite or other information. Failure to examine the Contract or other information does not relieve the Contractor of responsibility for the satisfactory completion of the work.

8. Fees and Permits

   a. In accordance with General Conditions Article GC7.4 (and associated Special Conditions), Contractor shall pay all required fees and obtain all

required permits related to the work specified herein and elsewhere in the Contract.

b. Royalties or fees in connection with the use of patented devices and systems shall be paid at no additional cost to the District.

c. Controlled inspection shall be provided where required by authorities having jurisdiction and by the Contract.

B. Installation Requirements

1. Install electrical materials, equipment, and accessories in locations as required, rigid and secure, plumb and level, and in alignment with related and adjoining work.

2. When installing conduits, supports, or structural members on existing concrete surfaces, x-ray scanning shall be used to determine location of embedded structural members. Installation of new equipment shall not impact structural integrity of existing structures in any way.

3. Install supporting members, fastenings, framing, hangers, bracing, brackets, straps, bolts, angles and anchoring as required to meet the seismic design requirements as specified herein and elsewhere in the Contract. Electrical materials shall not be welded for attachment or support.

4. Erection tolerance requirements shall not impair the strength, safety, serviceability, or appearance of the installations.

5. Contractor shall coordinate the Work with the Engineer in accordance with the following:

a. The Contract establishes overall installation scope, materials and quality but not all details or complete installation instructions. Contract drawings are diagrammatic.

b. The Contract shows the general arrangement of equipment and appurtenances. Follow the Contract as closely as the actual construction and the work of other trades will permit. Provide offsets, fittings, and accessories, which may be required but not shown on the Contract. Investigate the Jobsite, and review drawings of other trades to determine conditions affecting the work, and provide such work and accessories as may be required to accommodate such conditions.

c. The locations of infrastructure indicated on the Contract are subject to such revision as may be found necessary or desirable at the time the work is installed, or to meet field conditions, or to simplify the work, or for other legitimate causes. Exercise caution regarding the location of items. Provide precise and definite locations to the Engineer and have it accepted by the Engineer before proceeding with the installation.

d. The Contract shows estimated runs of raceways and locations of equipment. Any significant changes in location of equipment necessary to meet field conditions shall be brought to the immediate attention of the

Engineer for review and approval before such alterations are made. Modifications shall be made at no additional cost to the District.

e. Circuit tags in the form of numbers are used where shown to indicate the circuit designation numbers. Show the actual circuit numbers on the as-built record drawings and on the associated typed equipment enclosure directory card.

f. The Contract generally does not indicate the number of wires in conduit for the feeder and branch circuit wiring, or the actual circuiting. Provide the correct wire size and quantity as required by the indicated circuiting and circuit numbers indicated, the control intent, referenced wiring diagrams , the specified voltage drop or maximum distance limitations, and the applicable requirements of the NEC and CEC.

g. Furnish and set sleeves for passage of electrical risers through structural masonry and concrete walls and floors and elsewhere as required for the proper protection of each electrical riser passing through building surfaces.

h. Provide firestopping around all items including pipes, conduits ducts, and sleeves which pass through rated walls, partitions, and floors.

i. Provide required supports and hangers for conduit and equipment, designed so as not to exceed allowable loadings of structures.

j. Adjust location of items including to accommodate the work to prevent interferences, both anticipated and encountered.

k. Right-of-Way: Lines which slope have the right-of-way over those which do not slope. Lines whose elevations cannot be changed have right-of-way over lines whose elevations can be changed.

l. Provide offsets, transitions and changes in direction of conduit as required to maintain proper headroom and pitch on sloping lines.

6. Cutting and Patching shall be performed in accordance with the following:

a. Where cutting, channeling, chasing or drilling of floors, walls, partitions, ceilings or other surfaces is necessary for the proper installation, support or anchorage of conduit or other equipment, layout the work carefully in advance. Repair any damage to the building, piping, equipment or defaced finished plaster, woodwork, and metalworkusing skilled people of the trades required at no additional cost to the District.

b. Do not cut, channel, chase or drill unfinished masonry, tile, etc., unless permission from the Engineer is obtained. If permission is granted, perform this work in a manner acceptable to the Engineer.

c. Provide slots, chases, openings, and recesses through floors, walls, ceilings, and roofs as required.

d. Where these openings are not provided, provide cutting and patching to accommodate penetrations at no cost to the District.

7. Equipment and material shall be protected in accordance with the following:

a. Protect the work, equipment, and material of other trades from damage by work or workmen of this trade, and correct damage caused without additional cost to the District.

b. Take responsibility for work, materials, and equipment until finally inspected, tested, and accepted.

c. Protect work against theft, injury, or damage, and carefully store material and equipment received on the Jobsite, which is not immediately installed.

d. Close open ends of work with temporary covers or plugs during construction to prevent entry of obstructing material.

e. Cover and protect equipment and materials from damage due to water, spray-on fireproofing, construction debris, etc.

f. Store equipment subject to moisture damage in dry, heated spaces.

g. Provide adequate means for fully protecting finished parts of materials and equipment against damage from whatever cause during the progress of the work until final acceptance.

h. Protect materials and equipment in storage and during construction in such a manner that no finished surfaces will be damaged or marred, and moving parts are kept clean and dry.

i. Do not install damaged items. Take immediate steps to obtain a replacement item or repair the damaged item.

8. Mounting Heights

a. Unless otherwise specified on the Contract drawings and other sections equipment enclosures, install light fixtures, wiring devices, and static signage in accordance with the approved construction design deliverables and as specified herein:

1) Centerline of receptacles: 18 inches above finished grade.

2) Centerline of light switches and static signage: 48 inches above finished grade.

3) Top of equipment enclosures (wall and pedestal mounted) shall not exceed 6 feet, 6 inches above finished grade. Bottom of equipment enclosures (wall and pedestal mounted) shall be at least three feet above finished grade.

4) Blue light station’s light fixture shall not exceed 6 feet 6 inches above finished grade.

9. After installations are complete, surfaces shall be thoroughly cleaned. Where shop paint coating is missing or abraded bare steel is exposed, including bolts, nuts, washers, and welds, paint each item with the same paint system as used for shop painting. Provide touch-up painting by approved spray methods or brush where spray-painting is not practical.

C. Modifications to existing traction power facilities shall be in accordance with the following:

1. Refer to Section 01 35 14, Operating System Interface, for additional requirements relating to working on and adjacent to the operating system.

2. Survey the traction power facility, ancillary spaces and associated equipment, and underground structures. Verify the existing configuration (without interrupting or interfering with revenue service operations) and use it as a base for all modifications.

3. Coordinate and schedule Installation activities to ensure the District's revenue service operations are not disrupted during the performance of the work

4. Submit staging and implementation plans for the Work, including interface to existing operating System, testing and cut-over of both completed systems.

5. Provide the District with resource requirements to be supplied by the District (e.g. safety monitor support, safe clearances).

6. Implement an approved safety system prior to and during the execution of the Work.

7. Conduct pre-activity meetings with applicable stakeholders within the District and third-party utility service provider(s).

8. Install equipment, conduits, cable tray, cables, materials and appurtenances in accordance with the approved construction design deliverables to provide a complete and operable system.

9. Unless otherwise specified in the Contract, conduit extensions to existing operational installations shall match existing conduit sizes.

10. Reconfiguration and temporary disconnection of third party utilities shall be coordinated with the respective third party utility service provider(s).

11. Protect existing infrastructure in place during the execution of the Work.

12. Clearly delineate "new" Work from existing operational circuits. Provide signage communicating contact person(s), cellphone number(s) and restrictions.

13. Remove, replace, and salvage (as applicable) existing equipment, conduits, cable tray, cables, materials and appurtenances as indicated in the Contract.

14. Transport removed items off the District's right of way and dispose of items in accordance with Federal, State and local ordinances.

15. Coordinate firmware and software interfaces and changes with the District.

16. Restrain and electrically isolate un-terminated new conductors and associated termination hardware to prevent accidental contact with existing operation circuits.

17. The Contractor shall not terminate new conductors and fiber optic strands to existing operational circuits.

18. If construction activities impact revenue service operations and functionally impair or damage existing operational circuits, cease Work immediately and follow the direction of the Engineer.

D. Replace damaged Work prior to final acceptance at no additional cost to the District.

E. Refer to Section 34 21 01, General Requirements for the Traction Power System, and Contract drawings for additional requirements.

F. Review equipment vendor designs against the Contract drawings. Notify the Engineer of discrepancies and seek direction.

3.02 THIRD PARTY UTILITIES (TEMPORARY AND PERMANENT)

A. Refer to Section 01 11 00, Summary of Work, and Section 34 21 01, General Requirements for the Traction Power System, for additional requirements.

B. Submit permit applications with applicable design documentation to third party utility service providers and obtain approval prior to the commencement of construction activities.

C. Call Underground Service Alert or equivalent and affected utility companies two (2) Working Days (not including initial day of contact) in advance before digging, grading or excavating for the marking of underground member utilities.

D. Unless otherwise specified by the third-party utility service provider, comply with the following requirements:

1. Excavation, bedding, and backfill shall be in accordance with Section 33 05 28, Trenching and Backfilling for Utilities.

2. Clean excavation prior to placement of third party utility infrastructure.

3. Dewater all excavations in accordance with Section 31 23 19, Dewatering.

4. Provide a compacted aggregate base under underground structures in accordance with Section 32 11 24, Aggregate Drainage Layer, and Section 33 46 00, Subdrainage.

E. Field verify locations for existing utilities and suitability prior to beginning installation of the third-party utility infrastructure. Check with USA survey or other third party survey company to verify existing underground facilities prior to excavation. Discovery of conflicts with existing utilities and/or unsuitable conditions shall be immediately brought to the attention of the Engineer for review and direction.

F. Construct 3rd Third party utilities in accordance with the approved design, CPUC General Orders, third party utility service provider's construction requirements and the requirements specified herein or elsewhere in the Contract.

G. Provide appropriate safety barriers, ventilation and gas monitoring devices in accordance with CalOSHA requirements.

H. Schedule and undertake inspections of third party utility infrastructure with the respective third party utility representative(s) and the Engineer prior to backfilling and installation of concrete and equipment. Ensure applicable field tests have been completed and test records are available prior to inspections. Corrective work requiring approval shall be performed at no additional cost to the District.

I. Provide documentation to formalize acceptance (inspection and testing) by the third party utility service providers of the as-built utilities provided under the Contract.

3.03 EQUIPMENT PLACEMENT (AC AND DC EQUIPMENT HOUSES, TRANSFORMERS)

A. Refer to Specification Section 34 21 05 Article 3.05 and manufacturers' recommendations for requirements.

3.04 UNDERGROUND DUCTBANKS AND STRUCTURES

A. General

1. Comply with requirements specified in Art. 3.02 C to E inclusive and G above.

2. Install temporary covers to secure underground structures and associated field installed cables, and to prevent accidents.

3. Provide engraved contract number designations on each cable trench or vault cover (to cable trenches).

4. Schedule and undertake inspections of underground ductbanks and structures with the Engineer prior to backfilling and/or installation of concrete / equipment. Ensure applicable field tests have been completed and test records are available prior to inspections. Corrective work requiring approval shall be performed at no additional cost to the District.

5. Remove all construction material and debris from underground/precast structures, sump pump structures, cable trenches and ground wells prior to pre-final punchlist inspections, energization of LV and MV conductors, and/or operating optical networks.

6. Install permanent covers prior to pre-final punchlist inspections, energization of LV and MV conductors, and/or operating optical networks.

7. Provide permanent ladders on walls of all underground structures more than 36 inches deep (to cable trenches).

B. Underground Ductbanks

1. Underground ductbanks shall be installed in accordance with Section 20 50 16, Underground Ductwork and Structures for Facility Services.

2. Routing of electric utility underground ductbanks within the traction power facilities shall be minimized.

3. Mandrel and clean all conduits prior to cable/wire installation.

C. Precast Structures

1. Precast structures shall be installed in accordance with Section 33 05 16, Utility Structures.

D. Cable Trenches

1. Cast in place cable trenches shall be installed in accordance with Section 03 11 00, Concrete Forming, Section 03 05 15, Portland Cement Concrete, Section 03 20 00, Concrete Reinforcing, and Section 03 30 00, Cast-In-Place Concrete.

E. Sump Pump Structures

1. Cast in place sump pump structures shall be installed in accordance with Section 03 11 00, Concrete Forming, Section 03 05 15, Portland Cement Concrete, Section 03 20 00, Concrete Reinforcing, and Section 03 30 00, Cast-In-Place Concrete.

2. Sump pump precast structures shall be installed in accordance with Section 33 05 16, Utility Structures. Sump pump structures shall be separate from cable trenches.

F. Covers

1. Provide covers with embossed or engraved identification as indicated on the Contract Drawings and as specified in Section 33 05 16, Utility Structures.

2. Covers of underground/precast structures, sump pump structures, cable trenches and ground wells shall be installed flush with the finished grade.

3. Install security hardware on all covers within the traction power facility sites, along the alignment and in areas that are accessible by the public.

4. Covers for underground structures, that are accessible by the public and/or roadway vehicles (operated by non-BART entities), shall not protrude above finished grade when the security hardware is not properly installed and loose (i.e. have no spring assist features).

3.05 GROUNDING AND BONDING

A. Except for high-resistance grounded equipment, all other current carrying non-conductive entities (e.g. gates, handrails, gratings, electrical equipment enclosures, support structures, metallic raceways, metallic conduits, metallic cable trays, covers for underground structures and trenches, boxes, cabinets, exposed expansion joints, site lighting fixtures and mounting poles, and receptacles) shall be grounded as required by NEC, CEC, and as indicated on the Contract drawings.

B. Equipment grounding conductors shall be connected to the ground test stations within the AC or DC equipment houses, uniquely identified (correlating with the equipment they originate from) and shall be insulated from high-resistance grounded equipment.

C. Grounding and bonding of third party utility services shall be installed in accordance with the requirements of the respective third party utility service provider(s).

D. Grounding and bonding shall be installed and tested in accordance with Section 34 21 60, Grounding and Bonding for Traction Power Facilities.

3.06 EQUIPMENT/STRUCTURE / LIGHT FIXTURE POLE FOUNDATIONS, CONTAINMENT STRUCTURES AND STAIRWAYS

A. Third party electric utility equipment foundations, containment structures, equipment pads, shall be installed in accordance with the requirements of the third party electric utility service provider(s).

B. Cast in place equipment, structure and light fixture pole foundations, containment structures, and stairways shall be installed in accordance with Section 03 11 00, Concrete Forming, Section 03 05 15, Portland Cement Concrete, Section 03 20 00, Concrete Reinforcing, and Section 03 30 00, Cast-In-Place Concrete.

C. Support reinforcing steel with concrete blocks. Tie the reinforcing steel with steel wire to maintain spacing and clearances shown on the Contract drawings.

D. Unless otherwise specified do not weld reinforcing steel at laps or intersections.

E. Prior to pouring concrete use templates to accurately locate anchor bolts and leveling channels in accordance with the Contract drawings. Ensure no movement during the concrete pour and vibration.

F. Unless otherwise specified do not weld or bend anchor bolts and levelling channels.

G. Conduct the following concrete tests at each traction power facility site:

1. Slump test.

2. Air content test.

3. Strength test.

H. Apart from light fixture pole foundations and stairways, the footprint of equipment and house foundations shall extend not less than 4 inches larger in both directions beyond the actual equipment and house footprint.

I. The walls of containment areas shall extend not less than 4 inches larger in both directions beyond the actual equipment footprint for each oil filled transformer (inclusive of fins and valves).

J. Install the failsafe to close drain valve with oil detection in accordance with the Contract drawings and the manufacturer's recommendations.

K. The entrance landing to the AC and DC equipment houses, that has been designated for circuit breaker removal shall be sized and constructed to permit circuit breaker placement on it with door opened only 90 degrees.

L. Install embedments for gratings in equipment foundations and containment walls.

M. Install leveling channels in the foundations associated with the AC and DC equipment houses, rectifier transformers, auxiliary power transformers, 34.5 kV isolation disconnect switches and 34.5 kV junction cubicles.

N. Install the bottom of the containment wall's outlet at least 1 inch above finished grade exterior to the containment and account for accessibility to the outlet valve.

O. Install outlet valve(s) at each containment structure.

P. Coordinate offsets and stub-up locations of ground pigtails, conduits, sleeves, water supply and drainage pipes.

Q. Immediately after placement, protect concrete from premature drying, excessively hot or cold temperatures, and mechanical injury

R. Demolish foundations that allow standing water and install new foundations at no additional cost to the District.

S. Remove spalling in concrete surfaces.

T. Install grout at all openings between equipment and concrete surfaces.

U. Patch holes and/or openings in finished concrete surfaces.

V. Install yellow reflective striping on stairs and elevated curb thresholds at gates and/or walkways.

W. Install covers for the underground structures and cable trenches.

X. Install safety bars in all cable trenches in accordance with the Contract drawings.

Y. Verify that foundation grades, embedded leveling channels, and anchor bolt locations are correct and shall perform the following:

1. All leveling channels in each foundation shall vary from the horizontal by not more than 1/8 inch over the length of the leveling channel. Foundation leveling channels shall vary by not more than 1/8 inch with reference to other leveling channels over the length of the leveling channels. Where equipment vendor prescribes stricter installation tolerances, the more stringent requirements shall apply.

2. Level of the top of all foundation concrete shall be a minimum of 1/8 inch below top face of embedded leveling channels.

3. Top face of house foundation or equipment pad concrete shall vary by not more than 1/8 inch over entire foundation or equipment pad face.

Z. Submit field survey data confirming foundation adherence to required tolerances for each equipment house and equipment pad.

1. If the survey shows that leveling channels are not level to within required tolerances as specified above, channels shall be made level before setting of the equipment or house. Methods used to level channels shall be approved by the District, and shall meet all seismic requirements suitable for the construction in accordance with the approved seismic design.

2. If survey shows that the face of the pad or foundation concrete is out of the required tolerance, the high points shall be ground down to within the required tolerance before setting of the equipment or house.

3. If the survey shows the pad or foundation locations vary by more than plus or minus 1/8 inch, the Contractor shall correct the installation at no additional cost to the District.

4. AC and DC equipment house and rectifier transformer foundations shall vary by not more than 1/8 inch from locations depicted on the Contract drawings.

5. Efficacy of methods proposed to correct location, heights of foundation pads, or levels of equipment house leveling channels shall be confirmed by seismic calculations done by a Registered California Professional Structural Engineer, and shall meet all seismic requirements suitable for essential facilities as defined in the CBC and as required by Specification Section 34 21 01.

6. All calculations shall be submitted to the Engineer for approval.

7. Following approval of remediation methods and seismic design calculations, the Contractor shall perform all remedial actions necessary to bring foundation pad into construction tolerance.

8. Delivery and installation of AC and DC equipment houses and traction power transformers may occur only following District approval of foundation pad survey data and any required remediation calculations, remedial work, and re-survey of equipment pad by an independent third party surveyor.

3.07 SITE PERIMETER SECURITY BARRIER AND GATES

A. Perimeter security barrier and gates shall be installed in accordance with Section 03 30 00, Cast-In-Place Concrete Section 04 22 00, Concrete Unit Masonry, Section 05 50 00, Metal Fabrications, and Section 32 31 13, Chain Link Fences and Gates.

B. Install footings clear of third party utilities, underground ductbanks and structures, and ground grid components.

3.08 SITE FINISH, PARKING AND ACCESS ROADWAY

A. Site Finish

1. Refer to the Contract drawings and applicable Sections for requirements.

2. Grade the site finish material up around the cable trenches and underground structures to ensure a smooth transition between asphalt and surrounding material and effectively prevent water ingress into them.

B. Parking

1. Refer to the Contract drawings and applicable Contract sections for requirements.

C. Access Roadway(s)

1. Refer to the Contract drawings and applicable Contract sections for requirements.

3.09 MISCELLANEOUS EQUIPMENT

A. 35 kV Elbow termination enclosure shall be provided in accordance with the following:

1. Install 35 kV elbow termination enclosures at each traction power facility in accordance with Section 34 21 50, Common Materials and Methods for Traction Power and the approved construction design deliverables.

2. Ensure there is at least 8 feet horizontal clearance and a level working platform in front of the 35 kV elbow termination enclosures to permit hot stick operation.

3. Install vehicle barriers adjacent to the 35 kV elbow termination enclosures, where they are located at a point that can be accessed by O&M vehicles.

B. 35 kV Isolation Disconnect Switches shall be provided in accordance with the following:

1. Install 35 kV isolation disconnect switches at each traction power facility in accordance with Section 34 21 56, 35 kV Isolation Disconnect Switches and the approved construction design deliverables.

2. Ensure there is at least 8 feet horizontal clearance and a level working platform in front of the 35 kV isolation disconnect switches to permit hot stick operation.

3. Install vehicle barriers adjacent to the 35 kV isolation disconnect switches, where they are located at a point that can be accessed by O&M vehicles.

C. Site Lighting

1. Install site lighting fixtures, poles and mounting hardware shall in accordance with Section 26 50 00, Lighting, and the approved construction design deliverables.

D. Blue Light Stations

1. Install a blue light station within each traction power facility, 6 feet or less from the entrance gate, in accordance with Section 26 50 00, Lighting and the approved construction design deliverables.

E. Communications

1. Install communications equipment in accordance with Division 27, Communications, Section 28 10 01, Access Control Systems, and Section 28 41 29, Closed Circuit Television Systems, and the approved construction design deliverables.

F. Sump Pumps and Associated Equipment

1. Sump pumps, materials and associated equipment shall be installed in accordance with Section 22 14 29, Sump Pumps.

2. Install sump pump controllers at grade within the traction power facilities. Working clearances shall comply to NEC / CEC.

G. Wiring Devices shall be provided in accordance with the following:

1. Install wiring devices in accordance with Section 20 70 26, Common Materials and Methods for Electrical Systems, and Section 34 21 50, Common Materials and Methods for Traction Power.

2. Install switches, receptacles, special purpose outlets, and cover plates completely and neatly in accordance with California Electrical Code (CEC), and Section 20 70 26, Common Materials and Methods for Electrical Systems. Plug or cover unused openings in boxes, cabinets, and equipment.

3.10 STATIC SIGNAGE

A. Refer to Section 34 21 01, General Requirements for the Traction Power System, for requirements.

B. Refer to Contract drawings for mounting height and horizontal clearance requirements.

3.11 FIELD INSTALLED CONDUIT, CABLE TRAY AND BOXES

A. Install conduits, fittings and mounting hardware in accordance with the approved construction design deliverables, manufacturer's instructions, Section 20 50 13, Raceways for Facility Services, Section 26 05 29, Hangers, Supports and Seismic Protection, Section 26 05 53, Identification Requirements, Section 34 21 50, Common Materials and Methods for Traction Power, and as specified herein elsewhere in the Contract.

B. Install separate conduits for cables of different systems / applications / utilization voltage categories.

C. Metallic conduits entering high resistance grounded equipment shall be insulated from the equipment enclosures.

D. After installation of 34.5kV ac, 1000V dc positive and negative cables in trays, paint or tape the cables with fire-proofing materials.

3.12 FIELD INSTALLED CONDUCTORS/CABLES AND FIBER OPTIC CABLES

A. Furnish the following categories of cables as indicated in the Contract:

1. 35 kV ac cables and associated terminations, hardware and accessories.

2. 2.4 kV dc cables for the positive and negative feeders, and associated terminations, hardware and accessories.

3. 2.4 kV dc cables for dc switchgear load measuring circuits.

4. Low-voltage cables and wires between ac equipment house, rectifier transformers, dc equipment house, and other outdoor equipment within the traction power facility.

5. Fiber-optic and other communication cables and associated termination accessories, for interfacing the traction power facility with the District’s communication network; or, with other traction power facilities and devices.

B. Install and terminate cables, conductors and fiber optic strands in accordance with the approved construction design deliverables, cable manufacturer's instructions, Section 26 05 24, Low Voltage Wires and Cables, Section 27 13 01, Communication Cables and Related Equipment, and Section 34 22 23, Traction Power Cables, and as specified herein.

C. Cables shall be handled in such a manner as to prevent damage to the insulation. The ends of the cable shall be covered to prevent dirt and moisture from entering the cables during handling and installation. The cable shall be kept dry prior to and during installations and shall not be exposed to oil or grease.

D. Unless permitted by the NEC or CEC, cables of different systems/applications/voltage categories shall be routed in separate conduits. Fiber optic cables shall be routed and protected in accordance with EIA 568-B, TIA 606-A, NECA 301 and Section 27 13 01, Communication Cables and Related Equipment

E. Cable Pulling

1. Submit cable pulling calculations for cable pulls between equipment houses, between pads, and between traction power facilities and sites external to traction power facilities such as trainways. Calculation shall demonstrate that pull tensions and sidewall pressures are within acceptable tolerances. No cable pulls shall be undertaken prior to acceptance of cable pulling tensions by the District.

2. Cables shall be pulled directly into the conduits from cable reels. The pulling speed shall be limited so that the cables move smoothly into the conduit at a uniform velocity. Steel pulling lines shall not be used in non-metallic conduit. Where pulling grips are used, damaged ends shall be removed as soon as the cables have been installed.

3. Wherever two or more conductors are pulled into one conduit, the cables shall be uncoiled from the two or more reels simultaneously.

4. After installation, all exposed cables and those that are accessible shall be cleaned of dirt, grease, and pulling lubricant, using a commercial cable cleaner approved by the cable manufacturer.

F. Cables within the traction power facilities shall be continuous without splices.

G. Fiber Optic Cable Service loops shall be provided in accordance with the following:

1. Install a minimum of 50 feet service loop at both ends of each fiber optic cable run.

2. Coil up the service loop and secure it to a wall within ancillary spaces.

3. Coil the service loop (associated with interbuilding cables) and secure it within the underground structure nearest the DC switchgear house.

4. Five (5) feet service loop, at each end are required for each intrabuilding cable between the AC and DC equipment houses.

H. Low voltage circuits requiring external connections and all unused terminals on auxiliary contacts, devices, relays, and control switches shall be brought to accessible terminal blocks.

3.13 CABLE SPLICES AND TERMINATIONS

A. LV Cable Splices and Terminations

1. LV Cable splices and terminations shall be installed in accordance with Section 20 70 26, Common Materials and Methods for Electrical Systems, Section 26 05 24, Low Voltage Wires and Cables, and Section 34 21 50, Common Materials and Methods for Traction Power.

B. MV Cable Splice and Termination

1. MV Cable splice and termination shall be installed in accordance with Section 34 22 23, Traction Power Cables.

C. Fiber Optic Cable Splice and Termination

1. Fiber optic cable splice and termination shall be installed in accordance with Section 27 13 01, Communication Cables and Related Equipment.

D. Wire Terminations

1. Connectors and terminals shall have temperature ratings equal to or greater than those for the wiring and shall be in accordance with UL 486A and UL 486B.

2. Connections shall be made only at the terminals on the devices, on terminal blocks, or on the buses:

   a. No splices or taps shall be made between these terminal points.

   b. No more than two wires shall be connected to any terminal point.

   c. Connections shall be made by ring- or spring-type lugs with insulated compression sleeves. The insulated sleeve shall firmly grip the wire insulation, and the metallic portion shall firmly grip the strands of the conductor. The crimping tool and lugs shall be of a system design in which the crimping tool will not release until the crimp has been completed.

3. Low voltage circuits requiring external connections and all unused terminals on auxiliary contacts, devices, relays, and control switches shall be brought to accessible terminal blocks.

3.14 IDENTIFICATION

A. Identifiers shall be installed in accordance with Section 26 05 53, Identification Requirements and the Contract drawings.

B. Identify all used and spare equipment, 34.5 kV elbow enclosures, 34.5 kV isolation disconnect switches, enclosures, components, conduits, cable trays, underground ductbanks and covers, boxes, cables, termination points, wiring devices, conductors and fiber optic strands.

C. Identification content shall match the information contained in the approved construction design deliverables.

3.15 MISCELLANEOUS MATERIALS / APPURTENANCES

A. Fire Proofing and barriers shall be installed in accordance with the following:

1. Install fire proofing and barriers at all floor penetrations to the AC and DC equipment houses.

2. Patch or replace missing structural steel fire-proofing on the underside of AC and DC equipment houses. Coordinate with the Engineer whether to patch or replace the missing structural steel fire-proofing.

B. Rodent & Water Barrier

1. After all field installed cables have been tested and before final punchlist inspections, energization of LV and MV conductors, and operating optical networks, install rodent and water barrier at the following locations:

   a. Conduit stub-ups at rectifier transformers, 34.5 kV elbow enclosures, 34.5 kV isolation disconnect switches, and handholes.

   b. Conduit stub-outs at underground structures and cable trenches.

3.16 RESTROOM FACILITIES

A. Refer to the Contract drawings and applicable specifications for requirements.

B. Install footings clear of third party utilities, underground ductbanks and structures, and ground grid components.

3.17 SPARES PROVISIONS

A. Equipment

1. Refer to individual Sections and the Contract Drawings for the requirements.

B. Consumables

1. At least two items or 10 percent spares of general consumables (e.g. fuses, indication lights) shall be provided for each traction power facility.

C. Underground ductbanks and conduits

1. At least one or 10 percent of spare conduits, whichever is greater, shall be provided in each underground ductbank for each different system, application, and utilization voltage categories.

2. At least one or 10 percent of spare conduits, whichever is greater, shall be provided for each different system, application, and utilization voltage categories in each horizontal and vertical conduit runs between equipment enclosures, equipment enclosures and wireways within the AC and DC equipment houses.

D. Conductors and fiber optic strands

1. At least 20 percent spare conductors shall be provided for all multi-conductor control and indication cables.

2. At least 20 percent spare fiber strands shall be provided for all fiber optic cables (associated with the Traction Power System).

3. Terminate spare conductors and fiber optic strands and, ensure they are not electrically/optically connected to operational circuits.

E. Termination blocks/patch panels

1. Provide termination blocks and patch panels (fiber optic, multi-conductor and/or cat 6a) for the installed and future spare capacity (per Article 3.16 D herein) conductors and fiber optic strands.

3.18 INSPECTION AND TESTING

A. Inspect and/or test the AC & DC equipment houses, rectifier transformers, auxiliary transformers, 34.5 kV elbow enclosures, 34.5 kV isolation disconnect switches, LV equipment, underground structures, cable trenches, etc. in accordance with Section 34 21 80, Traction Power System Field Acceptance Testing.

B. All spare equipment, conductors and fiber strands shall be inspected and tested.

3.19 CLEANING

A. Refer to Section 01 74 14, Cleaning, for additional requirements.

B. Remove all waste materials from the Jobsite(s) at no additional cost to the District.

3.20 DEMOBILIZATION

A. Refer to Section 01 71 13, Mobilization, for additional requirements.

B. Remove construction tools, materials and temporary construction utilities from each traction power facility.

C. Ensure equipment is left in its post field tested condition(s) where the Contractor has accessed equipment enclosures post field testing activities.

D. In the case of equipment that is electrically and/or optically connected to the operating system the Contractor shall not access the equipment without formal permission from the Engineer. Where permission is granted, schedule equipment access with the Engineer and only access the equipment when the Engineer is present on-site.

3.21 CLOSEOUT PROCEDURES

A. **Refer to Section 01 77 00, Closeout Procedures, and Section 01 78 39, Project Record Documents, for the requirements.**

END OF SECTION 34 21 70

SECTION 34 21 75

TRACTION POWER FACILITY FUNCTIONAL FACTORY TESTING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Traction Power Facility Functional Factory Test Requirements.

1.02 OVERVIEW

A. General

1. The Contractor's testing program shall verify, validate, and document that the Traction Power Facilities have been designed, manufactured, constructed, assembled, installed, adjusted, calibrated and electrically connected to meet the approved design, operational, functional and performance requirements as specified in the Contract Documents and approved design and construction submittals.

2. The testing program shall implement a methodical and structured approach that demonstrates all circuits function as intended and failsafe if subjected to abnormal operating conditions.

3. Factory functional testing shall confirm facility interconnected equipment interfaces function correctly so that:

    a. Facility systems and equipment function as a complete operational facility in the factory.

    b. Facility systems communicate with and respond correctly to the OCC remote Integrated Computer System (ICS) and Emergency Backup Panels 1 and 2 (EBP1/EBP2) as simulated by the BART OCC simulator laptop. This will be provided by the District for the Supplier's use during factory testing.

    Functional factory testing shall prove that facility equipment performs successfully as a complete functional facility, including inter-facility equipment interfaces and connections with interfacing remote facilities and systems.

4. The inspections and tests specified in this Section and elsewhere in the Contract represent the minimum requirements. Where additional inspection and/or testing requirements are recommended by the respective equipment manufacturers and/or industry standards, include these requirements in the test documentation and processes.

5. Refer to Contract Specifications Section 01 45 24, Testing Program Requirements for test plan preparation, submittal, and reporting requirements. The Contractor shall have approved test plan and procedures before starting the factory tests described herein.

6. Refer to Section 01 78 55, Safety and Security Certification for safety certification requirements associated with the testing program.

1.03 ABBREVIATIONS/SYMBOLS

1. CPUC California Public Utilities Commission
2. EBP Emergency Backup Panel
3. ETP Emergency Trip Panel
4. ETS Emergency Trip Switch
5. ETTC Emergency Transfer Trip Cabinet
6. ETTS Emergency Transfer Trip System
7. HMI Human Machine Interface
8. ICS Integrated Control System
9. IPR Integrated Protection Relay
10. MPR Multi Function Protection Relay
11. OCC Operations Control Center
12. PLC Programmable Logic Controller
13. NGD Negative Grounding Device
14. NYMS New Yard Management System
15. RTAC Real Time Automation Controller
16. SBBS Sectionalization Breaker Blocking System

1.04 RELATED SECTIONS

A. Refer to the following Sections for requirements relating to inspection and testing activities:

1. Section 01 45 00, Quality Control
2. Section 01 45 24, Testing Program Requirements
3. Section 34 21 33, Control, Monitoring and Display Panel
4. Section 34 21 35, Emergency and Transfer Trip System
5. Other sections specified in Section 3.01.B herein.

1.05 MEASUREMENT AND PAYMENT

A. General: Functional Factory Testing will be measured for payment for testing of each traction power facility for which testing is completed with all test reports approved, in accordance with the Contract Specifications.

B. Payment: Functional factory testing will be paid for at the Contract unit price for each facility as indicated in the Bid Schedule of the Bid Form.

1.06 REFERENCES

A. Underwriters Laboratories

1. UL 486B UL Standard for Safety Wire Connectors

1.07 SUBMITTALS

A. Submit factory test plan within 30 Days of release for production for related equipment.

B. Submit factory test procedures including test procedure data sheets within 90 days of release for production for related equipment.

C. Submit relay test data within 10 Days of completed MPR and IPR relay testing.

D. Submit factory test reports within 10 Days of completed factory testing.

PART 2 – PRODUCTS

2.01 GENERAL

A. This Section includes the functional factory testing requirements for the fully assembled AC and DC house equipment included within traction power switching and sectionalizing stations, traction power substations, and gap breaker stations.

B. Completion of the factory tests and acceptance of test reports specified in the following Sections are prerequisites for the functional tests specified in this Section:

1. Section 26 24 24, Circuit Breakers and Panelboards
2. Section 27 13 01, Communications Cables and Related Equipment
3. Section 28 31 00, Fire Detection and Alarm System
4. Section 33 83 06, Radio Network Bidirectional Radio Amplifier System
5. Section 34 21 05, Prefabricated AC and DC Equipment Houses
6. Section 34 21 11, Multi-Function Protection Relay Equipment
7. Section 34 21 12, Integrated Protection Relay Equipment
8. Section 34 21 14, Energy and Power Quality Meter
9. Section 34 21 17, AC Switchgear (SF 6 Gas Insulated Type)
10. Section 34 21 18, AC Switchgear (Sealed Vacuum Type)
11. Section 34 21 19, Separate Insulated Connectors
12. Section 34 21 20, AC Busways
13. Section 34 21 21, Transformer-Rectifier Units, Oil Filled Transformer, Uncontrollable Rectifier
14. Section 34 21 22, Transformer-Rectifier Units, Dry Transformer, Reversible Controlled Rectifier
15. Section 34 21 25, DC Switchgear
16. Section 34 21 27, Liquid Immersed Type Auxiliary Power Transformers
17. Section 34 21 30, Negative Grounding Device
18. Section 34 21 33, Traction Power Control, Monitoring and Display Panel
19. Section 34 21 35, Emergency and Transfer Trip System

20. Section 34 21 40, DC Control Power System

21. Section 34 21 50, Common Materials and Methods for Traction Power

22. Section 34 21 56, 34.5 kV Isolation Disconnect Switches

C. All tests shall be carried out in accordance with detailed and pre-approved testing program plans, procedures, and data sheets.

D. Prior to commencement of factory acceptance testing to be witnessed by the Engineer ensure that:

1. Test plans and procedures have been approved.

2. AC and/or DC equipment houses and associated equipment, cabling, conduits, etc. are completely installed per the approved equipment vendor design.

3. All control and protective relay devices are programmed with correct operational parameters and in a condition ready for testing.

4. AC and/or DC equipment houses and associated equipment are cleaned.

The Engineer will attend factory testing as a witness only after receipt of certification that Items 1 through 3 above have been completed. The Contractor shall bear all costs associated with any cancellation, delay, and rescheduling of factory tests due to incompleteness of the equipment preparation for testing.

E. Where the test execution and associated test records deviates from the approved test procedures the Contractor shall demonstrate equivalency and conduct all the tasks within the approved test procedures at no additional cost to the District.

F. FAT punchlists shall be actioned and FAT reports are approved by the District prior to shipping equipment to site for field installation.

2.02 INSTALLATION VERIFICATION

A. Equipment Assembly Inspection: Verify the following:

1. Enclosures and equipment are anchored correctly.

2. Physical damage, cracked insulators, and tightness of connections, defective wiring, and general mechanical and electrical conditions are noted.

3. Record all part numbers and serial numbers, and equipment nameplate data and main coil identification numbers.

B. Verify presence of voltage shock hazard and arc-flash hazard warning safety labels (per NFPA 70E) and all other safety/warning labels/signage required by the equipment manufacturer, CalOSHA and/or as specified in Section 26 05 53, Identification Requirements, are visibly installed on the front side, and at other access points, of the equipment enclosures.

C. Verify the AC and DC equipment low voltage switchgear Interrupting Rating (IR), medium and high voltage switchgear Interrupting Rating, and the circuit breakers' Withstand Rating against mechanical and thermal stress of the first half-cycle of fault current to comply with Contract.

D. Verify Electrical AC and DC equipment labels are provided and indicate the bus configuration.

E. Grounding Connections Inspection: Verify that all enclosure, equipment, and relay grounding connections inside of the ac and dc equipment houses, and rectifier transformer ground connections are in place, and properly made. Verify using approved drawings, which shall be marked as to completion.

F. Verify all doors for correct gaskets, closing and latching, and padlock provisions.

G. Mechanical Integrity Tests:

1. Perform mechanical checks on the physical integrity of all equipment. These tests shall include, but shall not be limited to, verifying the correct alignment of the racking mechanism of all circuit breakers by withdrawing and inserting the breaker module, verifying interlocks, contact gap spacing, correct bus connection torquing and placing of torque marks, and checking up doors and access panels.

2. Interchangeability of like-rated ac and dc circuit breakers shall be confirmed. An AC and DC circuit breaker shall not be interchangeable with a switchgear cubicle designed for a circuit breaker with a different rating. Dc feeder circuit breakers shall not be interchangeable with dc cathode circuit breakers.

3. Verify correct mechanical and key interlocking.

H. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not available, use those specified in UL 486 A&B.

I. Settings and Calibration: Verify the proper settings of all relays, and other protective and control systems and devices.

J. Conform by bench testing or by injection of signals into installed equipment that all protective relays function in accordance with the approved relay coordination study and settings.

K. Verify space heater operation.

2.03 TRACTION POWER FACILITY FUNCTIONAL TEST

A. General

1. The following system-level tests shall be carried out on each AC and DC equipment house, rectifier-transformer control modules, negative grounding devices, and remote Emergency and Transfer Trip System (ETTS) components. Tests shall be done after the houses are completely assembled and wired and all equipment has successfully passed the specified design and production tests. Equipment such as the CISCO Ethernet network switch in the C02 panel and the ETTS logic controller in the ETTC cabinet shall have passed the required equipment-specific system factory tests and shall have been installed and wired in the DC equipment house.

2. During this phase of testing protective device parameters shall be set and their performance verified, including performance of equipment status LEDs and other indicators. Test records shall include tripping levels and relay setting curves that verify coordination between the DC MPR relays and their associated IPR relays.

B. Circuit Continuity Tests: Perform tests to verify the continuity of all power and control circuits interfacing between facility equipment, combined with inspection checks to confirm that all wiring is correctly terminated in accordance with approved control schematics and wiring diagrams. The wiring shall be checked completely, including interconnections between associated AC and DC equipment houses equipment where applicable, and at shipping splits, if required.

C. Dielectric Tests: Resistance tester (megger) with appropriate voltage output to confirm the insulation integrity of all power, control power, and hard-wired control and indication circuits and control power buses and confirm the isolation of the dc switchgear and rectifier enclosures from ground:

1. Test insulation resistance at 6.8 kV dc for one minute on the 1,000 V dc power buses to ensure there is no insulation breakdown along the main power path.

2. Test dc switchgear and rectifier enclosures (with Device 164 disconnected) and on insulated wall surfaces to confirm the integrity of the insulation from ground. The enclosures to ground insulation shall be tested with at least 6800 V dc applied for one minute.

3. Test high resistance floors at 2,500V dc for one minute using a six-inch square (minimum) weighted test plate with meter connected between the test plate and the DC house structure ground. Apply a high conductivity saline solution between test plate and floor surface to ensure good electrical contact. Test locations shall be 24 inches apart covering the entire floor surface. Perimeter locations shall be within six inches of the edge. Minimum isolation resistance shall be 1,000 megohms, minimum.

4. Test to verify the insulation integrity of control power buses and low voltage power and control cables and wiring with the end devices disconnected where appropriate at 1500 V AC for one minute or 1800 V ac for one second.

D. Fire Alarm System Tests:

1. After the fire alarm and smoke detection system is completely installed, it shall be tested for continuity and correct operation.

2. The fire alarm system for the entire facility shall be tested as a complete system. If elements of the AC and/or DC equipment house to be protected by the fire alarm system are absent from the factory test setup, system end devices (smoke detectors, pull stations, strobes) shall be provided as part of the test setup enabling test of the complete fire alarm system.

3. Check operational integrity of the detection chamber by applying smoke. Each ionization detector shall be operated to ensure that the indicating lamp at the annunciator panel is lit. After completion of the test, the ionization detectors shall be set for correct sensitivity.

E. System Level Production Test: Perform functional tests on all equipment, devices, and control circuits to verify that they function in accordance with the final approved control schematics, and meet the requirements of the Contract:

1. Verify that all ac and dc feeder breakers of like size and application are interchangeable.

2. Temperature Alarms and Devices. All high temperature alarms and devices shall be tested, their calibration and settings checked, and proper operation verified.

3. Undervoltage Relays. Tests to verify the pickup and dropout levels of the undervoltage relays shall be performed.

4. Door Interlocks: Tests to verify the proper functioning and operation of all door interlocks in the DC house such as those on the rectifier doors and the doors to the dc circuit breaker compartments shall be performed.

5. No load DC Negative Disconnect Switch Interlock: Test to verify proper functioning of the interlocking system between the no load DC negative disconnect switch and the main DC circuit breaker shall be performed.

6. Support Systems and Devices. Check the required settings of thermostats and humidistats for the space heaters, ventilation equipment, the facility air temperature alarm, and confirm the proper functioning of all support systems and devices, including those of the 125 V dc control power system.

7. Control and indication functions shall be tested for all circuits including relays, annunciator panel, local and remote indications, local and remote control, and shutdown.

8. Control and indication functions shall be checked for proper operation by actuating each contact that initiates a control operation or alarm indication, and then following the control sequence or signal propagation through the various associated devices to ascertain that the correct results and indications are obtained for each condition. A complete set of the job schematics and connection diagrams shall be maintained by the test department during the testing. Upon completion of a circuit check, that circuit shall be high-lighted by the test technician to indicate circuit sequence verification.

9. Actuation of contracts, as required to initiate an operation and to set up interlocking conditions, shall be performed in a manner that effectively simulates operating scenarios. Functional tests on controls of the 34.5 kV ac circuit breakers shall include comprehensive verification of all automatic transfer routines. Where a 34.5 kV test voltage is not available the Supplier shall provide test circuits to simulate equipment automatic transfer performance.

10. Functional Tests on controls of the 1000 V dc circuit breakers shall include verification of the load measuring, auto-reclosing, and non-reclosing sequences.

11. Reverse-Current Trip. The Contractor shall apply current in the reverse direction through each main dc circuit breaker to verify that the reverse-current trip device trips the associated circuit breakers at the minimum current setting, as required.

12. DC Equipment Enclosure Protective Scheme. The proper operation of the high-resistance frame grounding scheme in all modes shall be verified by tests involving application of high potential ac and dc control voltages to the dc switchgear enclosure (enclosure ‘hot’), as well as grounding of the dc switchgear enclosure (enclosure ‘grounded’).

13. System full voltage test shall be performed on the switchgear assemblies to verify voltage transducers and voltage multipliers/dividers primary input to secondary output.

14. Control Parameters. Verify the control parameters, configuration, and set points of all equipment with electronic (microprocessor-based) controls such as electronic relays, NGD and ETTS equipment.

15. Emergency and Transfer Trip System (ETTS). The emergency and transfer trip cabinet (ETTC) shall be installed and wired to connect with the dc switchgear and the C02 panel. Other ETTC cabinets and logic controllers that will operate at adjacent facilities in conjunction with the DC house ETTC shall be interconnected to simulate the complete system to be placed in service. Do factory testing per requirements of Specification Section 34 21 35, Article 3.04.

16. Control and Annunciator Panel (C02). BART will provide a test laptop that emulates remote controls and indications of the BART ICS, EBP1 and EBP2, and the NYMS for use during functional testing. These communicate through the BARTnet system using the communication protocol used by BART via the PLC in the C02 cabinet and the Ethernet switch in the C04 cabinet. Do testing per requirements of Contract Specifications Section 34 21 33, Traction Power Control, Monitoring, and Display Panel and Related Equipment, Section 3.04, Field Testing. The following functional tests shall be performed:

    a. AC and DC switchgear status shall be verified at the C02 annunciator panel, and confirmation shall be obtained that the correct status indications are sent to the ICS, EBP1, EBP2, and NYMS. Tests shall be done by operating the switchgear.

    b. Alarm functions at the switchgear shall be simulated at each device, and the correct indication verified at the C02 annunciator panel and the ICS, EBP1, EBP2, and NYMS.

    c. Tests shall demonstrate that the C02 software has been configured so that all required traction power facility equipment controls, indications, alarms, system and device status indications, and data downloads can be successfully passed and actuated between the traction power facility C02 panel, facility equipment interfacing with the C02 panel, and the appropriate remote terminals of the ICS, EBP1, EBP2, and NYMS systems as simulated using the C02 test laptop simulator.

    d. Control circuit functional testing shall be performed by actuating control switches on the C02 annunciator panel and observing the operation of the circuit breakers and associated status indications on the mimic panel.

    e. The correct operation of selector and lockout switches shall be verified between the C02 panel and the switchgear.

    f. Access to RTAC PLC, IPR, MPR, and NGD data and settings through the secondary Ethernet Port from a remote terminal shall be demonstrated.

17. Any wires that are not tested during the functional testing shall be tested by continuity test to confirm wiring accuracy to the approved schematic.

END OF SECTION 32 21 75

SECTION 34 21 80

TRACTION POWER SYSTEM FIELD ACCEPTANCE TESTING

PART 1 – GENERAL

1.01 OVERVIEW

A. Testing Program

1. The Contractor's field acceptance testing program shall verify, validate, and document the Traction Power System has been designed, manufactured, constructed, assembled, installed, adjusted, calibrated, and electrically connected to meet the approved design, operational, functional, and performance requirements as specified in the Contract Documents and, approved design and construction submittals.

2. The testing program shall implement a methodical and structured approach that demonstrates all circuits function as intended.

3. The testing program shall comprise of the following testing categories:

    a. Installation Verification (IV) tests.

    b. Discrete Equipment Field Functional (DEFT) tests.

    c. Traction power Facility Functional Tests (FFT).

    d. System Integration Tests (SIT).

4. The field acceptance testing specified in this Section and elsewhere in the Contract represents the minimum requirements. Where additional inspection and/or testing requirements are recommended by the respective equipment manufacturers and/or industry standards, include these requirements in the test documentation and processes.

B. Project objectives and design basis shall be in accordance with the following:

1. The project objectives and design basis (inclusive of operational, functional, and performance requirements) shall be verified and validated by the Contractor's testing program and shall be as embodied in the following documentation:

    a. Contract documents.

    b. Contractor's approved design and construction submittals.

    c. Requests for information.

    d. Change notices.

    e. Codes, standards, and local ordinances.

    f. Third-Party design and construction requirements.

C. Third-party utility services shall be inspected and tested in accordance with the requirements of the respective third-party utility service providers.

D. Definitions of Tests:

1. Installation Verification (IV) tests: Tests conducted following the installation of equipment, cables, and sub-systems, in their prescribed final placement. Tests are intended to demonstrate all equipment, cables, and subsystems are the correct model/configuration and installed and wired to the approved design; free from damage; and are suitable for operation.

2. Discrete Equipment Field Tests (DEFT): A sequence of tests applied to a unit under test to show that it functions correctly.

3. Traction power Facility Functional Tests (FFT): A sequence of tests applied to a traction power facility to show that it functions correctly.

4. System Integration Tests (SIT) – Testing on a complete, integrated system to show its compliance with its specified requirements. SIT shall include end-to-end testing with systems interfacing with the facility under test including ICS, EBP1, EBP2, NYMS, and remote terminals interfacing with the facility Ethernet maintenance channel(s).

5. Regression tests (Software) – Selective retesting of a system or component to verify that modifications have not caused unintended effects and that the system or component still complies with the specified requirements.

6. Retest (Equipment and Cables) – Retest of equipment and cables after corrective action undertaken to address a failed condition to verify compliance to the specified requirements.

1.02 SECTION INCLUDES

A. Grounding system tests.

B. Installation verification tests.

C. Separable insulated connector tests.

D. AC isolation disconnect switches tests.

E. AC load break/vacuum fault interrupter and/load break switches tests.

F. AC switchgear tests.

G. 34.5 kV AC busway tests.

H. 1,200V AC and DC bus duct tests.

I. Rectifier transformer tests.

J. Rectifier tests.

K. DC switchgear tests.

L. High resistance flooring tests.

M. DC control power system tests.

N. Auxiliary power transformer tests.

O. Negative grounding device tests.

P. Emergency and transfer trip system tests.

Q. Telephone and CCTV equipment tests.

R. Substation functional tests.

S. Short circuit test.

T. Ground fault test.

U. Train start test.

V. Commissioning.

1.03 ABBREVIATIONS AND SYMBOLS

1.	AC	Alternating Current
2.	ATO	Automatic Train Operation
3.	CFT	Contact Fiber Transceiver
4.	CPUC	California Public Utilities Commission
5.	DC	Direct Current
6.	DEFT	Discrete Equipment Field Tests
7.	EBP1	Emergency Backup Panel 1
8.	EBP2	Emergency Backup Panel 2
9.	ETP	Emergency Trip Panel
10.	ETS	Emergency Trip Switch
11.	ETTC	Emergency Transfer Trip Cabinet
12.	ETTS	Emergency Transfer Trip System

13.	FFT	Facility Functional Tests
14.	FOT	Fiber Optic Transceivers
15.	GBS	Gap Breaker Station
16.	HMI	Human Machine Interface
17.	HVAC	Heating, Ventilation and Air Conditioning
18.	ICS	Integrated Control System
19.	ID	Identifier
20.	I/O	Input / Output
21.	IOM	Input Output Module
22.	IPR	Integrated Protection Relay
23.	IVT	Installation Verification Tests
24.	kV	Kilovolts
25.	LV	Low Voltage
26.	MPR	Multi-Function Protection Relay
27.	MWS	Maintenance Work Station
28.	MR	Mad Russian
29.	NETA	InterNational Electrical Testing Association
30.	NGD	Negative Grounding Device
31.	MΩ	Mega-ohm
32.	NYMS	New Yard Management System
33.	OCC	Operations Control Center
34.	PLC	Programmable Logic Controller
35.	PTS	Platform Trip Switch
36.	ROW	Right of Way
37.	SBBS	Sectionalizing Breaker Blocking System
38.	SCADA	Supervisory Control and Data Acquisition

39. SIT System Integration Tests
40. V Volts
41. VLAN Virtual Local Area Network

1.04 RELATED SECTIONS

A. Refer to the following Sections for requirements relating to field acceptance testing activities:

1. Section 01 11 00 Summary of Work
2. Section 01 31 19 Project Meetings
3. Section 01 32 16 Construction Progress Schedules
4. Section 01 33 00 Submittal Procedures
5. Section 01 33 23 Shop Drawings, Product Data, and Samples
6. Section 01 35 14 Operating System Interface
7. Section 01 43 00 Quality Assurance
8. Section 01 45 00 Quality Control
9. Section 01 45 24 Testing Program Requirements
10. Section 01 77 00 Closeout Procedures
11. Section 01 78 39 Project Record Documents
12. Section 20 50 13 Raceways for Facility Services
13. Section 22 14 29 Sump Pumps
14. Section 23 81 00 Unitary HVAC Equipment
15. Section 26 05 17 Dry-Type Transformers
16. Section 26 05 24 Low Voltage Wires and Cables
17. Section 26 24 13 Switchboards
18. Section 26 24 24 Circuit Breakers and Panelboards
19. Section 27 13 01 Communication Cables and Related Equipment
20. Section 27 30 01 Telephone Systems
21. Section 28 10 01 Access Control System

22. Section 28 31 00 Fire Detection and Alarm System
23. Section 28 41 29 Closed Circuit Television System
24. Section 33 83 01 Radio Network Trunked Radio System
25. Section 33 83 03 Radio Network Antenna System
26. Section 33 83 06 Radio Network Bi-Directional Radio Amplifier System
27. Section 34 21 01 General Requirements for the Traction Power System
28. Section 34 21 05 Prefabricated AC and DC Equipment Houses
29. Section 34 21 11 Multi-Function Protection Relay Equipment
30. Section 34 21 12 Integrated Protection Relay Equipment
31. Section 34 21 13 Contact Rail System
32. Section 34 21 14 Energy and Power Quality Meter
33. Section 34 21 19 Separable Insulated Connectors
34. Section 34 21 20 AC Busways
35. Section 34 21 21 Transformer-Rectifier Units, Oil Filled Transformer, Uncontrollable Rectifier
36. Section 34 21 22 Transformer-Rectifier Units, Dry Transformer, Reversible Controlled Rectifier
37. Section 34 21 27 Liquid Immersed Type Auxiliary Power Transformers
38. Section 34 21 30 Negative Grounding Device
39. Section 34 21 33 Traction Power Control, Monitoring and Display Panel, and Related Equipment
40. Section 34 21 35 Emergency and Transfer Trip System
41. Section 34 21 40 DC Control Power System
42. Section 34 21 50 Common Materials and Methods for Traction Power
43. Section 34 21 55 Manual DC Disconnect Switch
44. Section 34 21 56 35KV Isolation Disconnect Switch
45. Section 34 21 60 Grounding and Bonding for Traction Power
46. Section 34 22 23 Traction Power Cables

1.05 MEASUREMENT AND PAYMENT

A. General: Field testing will be measured for payment for testing of each traction power facility for which testing is completed with all test reports approved, in accordance with the Contract Specifications.

B. Payment: Field testing will be paid for at the Contract unit price for each facility as indicated in the Bid Schedule of the Bid Form.

1.06 REFERENCES

A. All inspections and tests shall be in accordance with the following codes, standards, and specifications except as provided otherwise herein. Where requirements conflict with requirements specified herein the more restrictive requirements shall apply.

B. American Society for Testing of Materials (ASTM):

1. ASTM D92 — 12 Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester
2. ASTM D445 — Standard Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)
3. ASTM D877/D877M — Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes
4. ASTM D923 — Standard Practices for Sampling Electrical Insulating Liquids
5. ASTM D924 — Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids
6. ASTM D1298 — Standard Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method
7. ASTM D1533 — Standard Test Method for Water in Insulating Liquids by Coulometric Karl Fischer Titration
8. ASTM D3612 — Standard Test Method for Analysis of Gases Dissolved in Electrical Insulating Oil by Gas Chromatography

C. CalOSHA – Electrical Safety Orders

D. International Electrotechnical Commission (IEC)

1. IEC61850 — Communication Network and Systems in Substations

E. Institute of Electrical and Electronics Engineers (IEEE)

1. IEEE 48	IEEE Standard Test Procedures and Requirements for Alternating- Current Cable Terminations 2.5 kV through 765 kV
2. IEEE 400	IEEE Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems
3. IEEE 400.1	Guide for Field Testing of Laminated Dielectric, Shielded AC Power Cable Systems Rated 5 kV to 500 kV Using High Voltage Direct Current (HVDC)
4. IEEE 400.2	Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF) (less than 1 Hz)
5. IEEE C37.20.1	Standard for Metal-Enclosed Low-Voltage (1000 Vac and below, 3200 Vdc and below) Power Circuit Breaker Switchgear
6. IEEE C37.20.3	Standard for Metal-Enclosed Interrupter Switchgear
7. IEEE C57.12.90	Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers
8. IEEE 1653.2	IEEE Standard for Uncontrolled Traction Power Rectifiers for Substation Applications Up to 1500 V DC Nominal Output
9. IEEE 4	Standard for High Voltage Testing Techniques

F. International Electrical Testing Association (NETA)

1. NETA ATS	Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

G. National Fire Protection Association (NFPA)

1. ANSI/NFPA 70	National Electrical Code
2. ANSI/NFPA 70B	Recommended Practice for Electric Equipment Maintenance
3. ANSI/NFPA 70E	Standard for Electrical Safety in the Workplace
4. ANSI/NFPA 101	Life Safety Code
5. ANSI/NFPA 110	Emergency and Standby Power Systems
6. ANSI/NFPA 130	Standard for Fixed Guideway Transit and Passenger Rail
7. ANSI/NFPA 780	Installation of Lightning Protection Systems

H. State and local codes and ordinances

I. Underwriters Laboratories, Inc. (UL)

1.07 TESTING RESPONSIBILITIES

A. Refer to Section 01 45 24 for:

1. Testing responsibilities
2. Requirements for testing organizations and test personnel
3. Test documentation
4. Test schedules
5. Traction power system studies
6. Rejection and retesting and regression testing
7. Test equipment calibration
8. Safety requirements

1.08 SUBMITTALS

A. Refer to the following Sections for additional requirements:

1. Section 01 33 00 Submittal Procedures.
2. Section 01 33 23 Shop Drawings, Product Data and Samples.

B. Submit the following documents for all equipment, cables and software provided under the Contract for the Traction Power System:

1. Qualifications and resumes of testing personnel: 30 Days before NTP.
2. Test program plan: Plus 180 Days prior to start of field acceptance testing.
3. Overall Field Testing Schedule: 120 Days prior to field acceptance testing with updates provided per Section 01 32 16, Construction Progress Schedules.
4. Schedule (four (4) week look ahead): Weekly (part of progress report to Engineer).
5. Checklists: 90 days before the start of the respective test.
6. Independent transformer oil and battery testing organizations: 90 days before start of the respective test.
7. Independent surveyor qualifications: 90 days before surveys are conducted.

8. Test procedures: 90 days before the start of the respective test.
9. General test data sheets: 45 days before the start of the respective test.
10. Site specific test data sheets: 30 days before the start of the respective test.
11. Test records shall be submitted in accordance with the following:
    a. Unofficial test results within twenty fours (24) hours of completing the test.
    b. Official test results within 10 days of completing the test.
12. Issues Tracking Logs: Weekly (as part of progress report submitted to the Engineer).
13. Energization plan: 90 days before energization of the traction power system
14. Test documentation metrics – Weekly (as part of progress report to the Engineer).
15. Project Closeout Test Documents.
16. Incident Reports – Within 12 hours.

C. Prior to commencement of a test, the records for pre-requisite inspections and test(s) shall be submitted to and approved by the District and any outstanding discrepancies shall be completed.

D. Prior to substantial completion, the following shall apply:

1. All testing, retesting and regression testing activities have been completed.
2. All FAT and field inspection punch list and testing discrepancies have been corrected, closed out and disposition with the District approval.
3. Configuration control documentation is up to date for the completely tested as-built traction power facilities.
4. All test records have been submitted and approved by the District.
5. Safety certification documentation is complete, submitted to and approved by the District.
6. Independent transformer oil testing laboratory and battery testing organization certifications, submitted, and approved by the District.
7. Independent surveyor qualifications submitted to and approved by the District.
8. Follow test plans, procedures, and test reports for all tests specified in associated contract specifications section noted herein in Article 1.02, related contract specifications sections.

9. Include test plans and procedures for Installation Verification tests and for tests of all ac and dc equipment houses, rectifier transformers, and other ancillary equipment, either provided by the Contractor or by Others as part of the facility being tested.

E. Submit test reports for all equipment provided at each work location for:

1. Portable TPSS AC Vacuum Fault Interrupter (VFI), in accordance with Section 34 21 07, Prefabricated Portable Substations.

2. 35 kV AC Cable, in accordance with Section 34 22 23, Traction Power Cables.

3. DC Cable, in accordance with Section 34 21 23, Traction Power Cables.

4. AC Switchgear, in accordance with AC Switchgear Tests, in this section.

5. 1200A Bus Duct and DC Cable, in accordance with 1200A Bus Duct and DC Cable Tests, in this section.

6. Rectifier Transformers, in accordance with Rectifier Transformer Tests, in this section.

7. Rectifiers, in accordance with Rectifier Tests, in this section.

8. DC Switchgear, in accordance with DC Switchgear Tests in this section.

9. High Resistance Flooring, in accordance with House High Resistance Flooring Tests, in this section.

10. Auxiliary Power Transformers, in accordance with Auxiliary Power Transformer Tests, in this section.

11. Separable Insulated Connector in accordance with Separable Insulated Connector, in this section.

12. AC Isolation Disconnect Switches in accordance with AC Isolation Disconnect Switches, in this section.

13. Manual DC Disconnect Switches, in accordance with Manual Disconnect Switches, in this section.

14. 125V DC Control Power System, in accordance with DC Control Power System Tests, in this section.

15. Negative Grounding Devices, in accordance with Negative Grounding Device Tests, in this section.

16. CO2 Panel in accordance with Article Panel Tests in this section.

17. Emergency Transfer Trip System, in accordance with Emergency Transfer Trip System (ETTS) Tests, in this section.

18. CCTV Equipment, in accordance with Section 28 41 29, CCTV Equipment.

19. Telephone Equipment, in accordance with Section 27 30 01, Telephone Equipment.

20. Access control equipment, in accordance with Section 28 10 01, Access Control System.

21. Fire detection and alarm system, in accordance with Section 28 31 00, Fire Detection and Alarm System.

22. Radio system, in accordance with Section 33 83 01, Radio Network Trunked Radio System, Section 33 83 03, Radio Network Antenna System, and Section 33 83 06, Radio Network Bi-Directional Radio Amplifier System.

F. Submit TPSS Field Acceptance Test reports in accordance with Substation Field Acceptance Tests, in this section.

1.09 GUARANTY/WARRANTY

A. Tests shall not alter the Contractor's guaranty and warranty of the Traction Power System. Replace and retest work and materials found to be in noncompliance with the Contract Documents at no additional cost to the District.

PART 2 – PRODUCTS

A. Not Used

PART 3 – EXECUTION

3.01 GENERAL

A. All tests shall be carried out in accordance with detailed and pre-approved testing program plans, procedures and data sheets.

B. Testing specified in this Section shall only be performed following completion of equipment and cable installation and associated punch list items.

C. Test of the telephone access control, CCTV, radio, and SCADA systems shall demonstrate functionality of the entire end-to-end systems and shall be done according to requirements of applicable specification sections:

1. Section 27 30 01 Telephone Systems

2. Section 28 10 01 Access Control Systems

3. Section 28 31 00 Fire Detection and Alarm System

4. Section 28 41 29 Closed Circuit Telephone System

5. Section 33 83 01 Radio Network Trucked Radio System

6. Section 33 83 03 Radio Network Antenna System

7. Section 33 83 06 Radio Network Bi-Directional Radio Amplifier System

8. Section 34 21 33 Traction Power Control, Monitoring and Display Panel, and Related Equipment

D. MV cable (35 kV, 2.4 kV, 1000 V), LV cable (LV power, controls and indications) and fiber optic cable test requirements are specified in Section 34 22 23, Traction Power Cables, Section 26 05 24, Low Voltage Wires and Cables, and Section 27 13 01, Communication Cables and Related Equipment, respectively.

E. LV power equipment test requirements are specified in the following Sections:

1. Section 26 05 17 Dry-Type Transformers

2. Section 26 24 13 Switchboards

3. Section 26 24 24 Circuit Breakers and Panelboards

F. Emergency and transfer trip system equipment test requirements are specified in Section 34 21 35, Emergency and Transfer Trip System.

G. Ground grid test requirements are specified in Section 34 21 60, Grounding and Bonding for Traction Power Facilities.

H. Testing activities shall be coordinated and scheduled with the Engineer, and account for constrains imposed by any of the following:

1. Scheduled revenue services and special events.

2. Availability of District resources and personnel.

3. Track or traction power facility access.

4. The District’s standard operating procedures.

5. Schedule maintenance and renewal activities by District personnel.

6. Schedule activities of other contractors working on and adjacent to the area of the Work.

I. Where test execution and associated test records deviate from approved test procedures, the Contractor and its Sub-contractors shall demonstrate equivalency and conduct additional tasks within the approved test procedures at no additional cost. Deviation from requirements shall be approved by the District in writing, and deviations not approved shall require retesting per District requirements at no additional cost.

J. Installation punch list and testing discrepancies shall be categorized under the following categories:

1. Safety Related
2. Code Violations
3. Contract, Design Non-Compliances or both.
4. Critical Operational Requirements
5. Non-Safety Related

3.02 TEST INSTRUMENTS AND TOOLS

A. Contractor shall furnish at a minimum, the following test tools and instruments for use in field testing:

1. Fiber optic cable test equipment.
2. Ground grid fall of potential type test equipment.
3. Torque wrenches.
4. Di-electric withstand (hi-potential) tester capable of generating voltages up to 80 kV.
5. Insulation resistance (megger) tester capable of performing tests up to 5 kV.
6. Low resistance ohm-meter.
7. 1,500V dc power supply.
8. 480V ac power supply.
9. Voltage and current signal generators.
10. Meters as necessary to measure specified testing and commissioning electrical data.
11. Noise meters.
12. Thermal imaging equipment.
13. Other test equipment that is required to sufficiently test equipment to confirm performance required by this Contract.

B. All test tools and instruments shall be certified in accordance with Contract Specifications Section 01 45 24, Testing Program Requirements.

3.03 INSTALLATION VERIFICATION TESTS

A. Equipment Assembly Inspection shall be performed by verifying the following:

1. All equipment shipping bracing has been removed.

2. Enclosures and equipment are anchored correctly and are level, with all seismic anchors and supports correctly installed.

3. Assembled on-site houses and equipment, including components and accessories, are correctly installed and labeled in accordance with approved shop drawings, and are in operable condition.

4. Physical damage, cracked insulators, and tightness of connections, defective wiring, and general mechanical and electrical conditions are noted.

5. Record all part numbers and serial numbers, and equipment nameplate data and main coil identification numbers.

B. Verify presence of voltage shock hazard and arc-flash hazard warning safety labels (per NFPA 70E) and all other safety, warning labels, and signage required by the equipment manufacturer and CalOSHA are visibly installed on the front side, and at other access points, of the equipment enclosures.

C. Grounding connections inspection shall be performed by verifying the following

1. Verify that all enclosure, equipment, and relay grounding connections inside and outside of the ac and dc equipment houses, and rectifier transformer ground connections are in place, and properly made.

2. Verify using approved drawings, which shall be marked as to completion.

D. Each portable TPSS and permanent TPSS rectifier transformer oil containment vessel or structure is watertight shall be verified by performing the following:

1. Fill containment vessel with water to a depth of two (2) inches for one (1) 24-hour period.

2. If test is done in rainy weather with damp ground structure around containment vessel, use a small amount of dye in the test water to verify that test water does not leak outside of the containment.

3. Following test, verify that opening of containment drain valve results in draining all test liquid from the containment structure or vessel.

E. Verify all control power connections, including alarms, trips, lights, heaters, and control power operations meet specified requirements. 34.5 kV incoming primary power connections and secondary bus connections shall not be made during Installation Verification Tests. Verify using approved drawings, which shall be marked as to completion.

F. Verify 480V ac auxiliary transformer wiring, neutral and tap jumpers are installed correctly and identified.

G. Verify that each battery system interconnection is torqued to manufacturer's recommended torque value.

H. Verify all doors for correct gaskets, closing and latching, and padlock provisions. Temporary locks shall be provided for securing the enclosures.

I. Mechanical Integrity Tests:

1. Perform mechanical checks on the physical integrity of all equipment. These tests shall include, verifying the correct alignment of the racking mechanism of all circuit breakers by withdrawing and inserting the breaker module, verifying interlocks, contact gap spacing, correct bus connection torqueing and placing of torque marks, confirming correct switch blade alignment, good blade contact pressure when closed, adequate blade separation when open, and checking all doors and access panels.

2. Perform mechanical checks on the physical integrity of all 34.5 kV ac switchgear equipment. These tests shall be performed to demonstrate proper operation of the interlocking system between the vacuum circuit breakers and the associated three position disconnector and grounding switches.

3. Interchangeability of like-rated dc feeder breakers shall be confirmed. A dc feeder breaker shall not be interchangeable with a switchgear cubicle designed for a circuit breaker with a different rating. Dc feeder circuit breakers shall not be interchangeable with dc cathode circuit breakers.

4. Verify correct mechanical and key interlocking. Transfer extra Kirk Keys to a secure location as directed by the District.

J. Tighten electrical connectors and terminals per manufacturer's published torque-tightening values. If manufacturer's torque values are not available, use those specified in UL 486A and UL 486B. The Engineer will check torque values of at least 10 percent of each type of bolted connection. If any torque value fails to meet torque criteria, then all bolted connections of that type shall be checked for correctness.

K. Settings and Calibration: Verify the proper settings of all relays, and other protective and control systems and devices. Settings, including software parameters and configuration, shall be per approved coordination study. Confirm correct ratings of medium voltage fuses.

L. Confirm by injection of signals that all equipment, potential transformers, and current transformer polarities are correct, for:

1. Vacuum fault interrupter

2. Rectifier transformers

3. 34.5 kV ac switchgear

M. Confirm by bench testing or by injection of signals into installed equipment that all protective relays function in accordance with manufacturer's published data.

N. DC control power system checks shall verify and ensure the following:

1. Each inter cell connection is tight
2. All battery post seals are intact
3. All shipping caps are replaced with vent caps

O. Verify space heater operation

P. Verify correct voltages at all receptacles

Q. Weatherproofing tests: Following installation of each substation enclosure, complete with throat connection assemblies and dc cable bus enclosures shall be tested in accordance with IEEE C37.20.1. Contactor shall also test each AC bus duct and associated connections to the rectifier transformer and DC equipment house to the same standard.

R. Inter-cabinet field installed wiring: Verify each wire is correctly terminated and continuity based on Contractor prepared interconnection diagrams.

S. Confirm correct AC switchgear SF6 gas pressure. If SF6 pressure is lower than manufacturer's recommended value, then the equipment shall be replaced at no cost.

T. All equipment shall be inspected in accordance with Article 3.03, Equipment Assembly Inspection.

3.04 DISCRETE EQUIPMENT FIELD FUNCTIONAL TESTS

A. General

1. Field engineering and quality control associated with field testing activities shall be performed in accordance with the requirements specified in the following Sections:
   a. Section 01 43 00 Quality Assurance
   b. Section 01 45 00 Quality Control
   c. Section 01 71 23 Field Engineering
2. Furnish equipment for testing power, lighting and control circuits after installation, including service test kit.
3. During this phase of testing protective device parameters shall be set and their performance verified, including performance of equipment status LEDs and other indicators.

4. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest at no additional cost to the District.

5. For all tests provide test instrument certification data and pass/fail criteria, and record date, time, temperature, humidity, voltage levels, and leakage current, meg-ohms, or resistance values, as applicable.

B. AC isolation disconnect switches tests

1. Tests shall be performed on all 34.5 kV switches prior to connecting 35 kV cables.

2. Resistance tests shall be performed in accordance with the following:

   a. Using a low-resistance ohmmeter, check resistance of bolted bus connections and of closed switch contacts of each phase.

   b. For each switch tested, if the resistance of any phase differs by more than 50 percent from the lowest value among phases of that switch, take remedial measures to bring high value to within 50 percent of the lowest value, and retest.

3. Insulation resistance tests shall be performed in accordance with the following:

   a. Perform insulation resistance (megger) tests at 5,000 volts for one minute at each switch pole, phase-to-phase, and phase-to-ground with the switch closed and across each open pole.

   b. Measured insulation resistance shall be 20,000 megaohms, minimum.

   c. Repeat insulation resistance tests following completion of dielectric withstand tests.

4. Dielectric withstand tests shall be performed in accordance with the following:

   a. With the switching device contacts closed, perform dielectric withstand (high potential) tests at 50 kV for five minutes between each phase of the switch with the frame and other phase grounded.

   b. With the switch contacts open, perform dielectric withstand (high potential) tests at 50 kV for five minutes between each phase of the switch with the frame, the other phase, and parts of the switch buswork not under test grounded.

   c. Measured leakage current across open contacts of each phase shall be less than 10 microamps maximum or manufacturer’s recommended value, whichever is less.

C. AC Vacuum Fault Interrupter Tests

1. Equipment shall be completely assembled, equipped with devices, installed, and field tested in accordance with NETA ATS requirements.

D. Manual DC Disconnect Switch Tests shall be performed in accordance with the following:

1. Perform dielectric (HiPot) tests on the equipment after installation in the field, in accordance with the manufacturer's recommended field testing.

    a. Apply minimum 4.6 kV AC phase and each phase to ground for 1 minute. No breakdown or failure shall occur.

2. Test contact resistance to confirm manufacturer’s recommended value is met.

3. Perform functional and operational tests to verify that equipment functions in accordance with requirements specified herein, including proper status indication at the associated traction power facility and the Operations Control Center (OCC).

E. AC Switchgear Tests

1. General

    a. Tests shall be performed on all 34.5 kV ac circuit breakers and ac switchgear bus assemblies and three position disconnector switches.

    b. Tests shall be performed prior to connecting 35 kV cables and switchgear instrument transformers, and with AC bus duct disconnected from ac switchgear bus or from the line side of the disconnector switches and load side of the circuit breakers.

    c. Tests shall be performed with potential transformer leads disconnected from the ac switchgear bus.

2. Circuit Continuity Tests – Perform continuity checks to verify current transformer connections, shunt leads, and all medium voltage fuses.

3. Resistance tests shall be performed in accordance with the following:

    a. Using a low-resistance ohmmeter, check resistance of all bolted bus connections, including instrument transformer connections, and of closed circuit breaker contacts of each phase of each circuit breaker.

    b. For each AC switchgear line-up tested, if the resistance of any phase differs by more than 50 percent from the lowest value among phases at that line-up, take remedial measures to bring high value to within 50 percent of the lowest value, and retest.

4. Insulation resistance tests shall be performed in accordance with the following:

    a. Perform insulation resistance (megger) tests at 5,000 volts for one minute at each circuit breaker pole, phase-to-phase, and phase-to-ground with each circuit breaker closed, and across each open pole.

    b. Perform insulation resistance tests at 5,000 volts for one minute at each current transformer connection, coil-to-ground.

c. Perform insulation resistance tests at 5,000 volts for one minute at each potential transformer pole, primary-to-ground with secondary winding grounded.

d. Measured insulation resistance shall be 20,000 MΩ, minimum.

e. Repeat insulation resistance tests following completion of dielectric withstand tests.

5. Dielectric withstand tests shall be performed in accordance with the following:

a. With the switching device contacts closed, perform dielectric withstand (high potential) tests at 60 kV for five minutes between each phase with the circuit breaker or between each phase of the combined disconnector switch and circuit breaker with the frame and other phases grounded.

b. With the switching device contacts open, perform dielectric withstand (high potential) tests at 60 kV for five minutes between each phase with the circuit breaker or between each phase of the combined disconnector switch and circuit breaker with the frame and other phases grounded.

c. Measured leakage current across open contacts of each phase shall be less than 10 μA, maximum or manufacturers recommended value, whichever is less.

F. 1200V AC bus duct tests shall be performed in accordance with the following:

1. General

a. Tests shall be performed on all 1,200V bus duct assemblies connecting traction power transformers and rectifiers.

b. Tests shall be performed with bus duct sections assembled, and bus duct disconnected from transformer and rectifier, and dc power cable connections disconnected from the rectifiers and dc switchgear.

c. Prior to testing, inspect and confirm that all bolted connections are torqued to values specified, and torque marks indicating correct torque are clearly marked. Record torque value for each connection in test report.

2. Resistance tests shall be performed in accordance with the following:

a. Using a low-resistance ohmmeter, check resistance of each bolted bus connection of each phase.

b. For each bus duct or cable connection tested, if the resistance of any phase differs by more than 50 percent from the lowest value among phases at that bus duct or cable connection, take remedial measures to bring high value to within 50 percent of the lowest value, and retested.

3. Insulation resistance tests shall be performed in accordance with the following:

a. Perform insulation resistance (megger) tests at 2,500 volts for one minute for each phase, phase-to-phase and phase-to-ground (per NETA 7.1.1).

b. Measured insulation resistance shall be 1,000 MΩ, minimum (per NETA 7.1.1).

c. Repeat insulation resistance test following completion of dielectric testing.

G. Rectifier Transformer Tests

1. General

a. Tests shall be performed on all rectifier transformers, per IEEE C57.12.90.

b. Tests shall be performed prior to connecting line side 35 kV connectors and cables and load side 785V system cables.

c. Prior to energizing transformer, note oil pressure, temperature, and hot-spot indicator readings for comparison with readings following energization.

2. Turns Ratio Tests – Perform turns ratio tests at all tap positions, per IEEE C57.12.90.

3. Insulation resistance tests shall be performed in accordance with the following:

a. Perform insulation resistance (megger) tests at 5,000 volts for one minute from primary transformer windings to each group of secondary transformer windings. Conduct tests with secondary windings grounded. Note that the traction power transformers have three (3) sets of windings: primary delta, secondary delta, and secondary wye.

b. Measured insulation resistance on the primary side shall be 1,000 MΩ minimum.

c. Perform insulation resistance (megger) tests at 2,500 volts for one minute from each group of secondary transformer windings to primary side transformer windings. Conduct tests on each group of secondary windings with the other secondary winding group grounded and the primary windings grounded.

d. Measured insulation resistance on the secondary side shall be 1,000 MΩ, minimum.

e. Repeat insulation resistance tests following completion of dielectric testing.

4. Dielectric withstand tests shall be performed in accordance with the following:

a. Perform dielectric withstand (high potential) tests at 60 kV AC for five minutes on each primary winding with the secondary windings grounded.

b. Perform dielectric withstand tests at 8.5 kV AC for five minutes on each secondary winding with the windings not under test grounded.

5. Insulating Oil Tests shall be performed in accordance with the following:

a. For each rectifier transformer, remove a sample of insulating liquid in accordance with ASTM D923, and test for the following:

1) Dielectric breakdown voltage: ASTM D877.

2) Dissolved-gas analysis: ASTM D3612.

3) Flash Point ASTM D924.

4) Fire Point ASTM D92.

5) Specific Gravity ASTM D1298.

6) Fire point test.

7) Check oxygen content and total combustible gas content of nitrogen gas cushion in sealed tank transformers. A total combustible gas test, where applicable, and a dissolved gas-in-oil test of the dielectric fluid should also be made soon after the transformer is in service at operating temperature to provide a suitable post-energization reference “bench mark”.

b. If oil does not completely fill containment tank, inject inert gas as required by manufacturer’s instructions.

H. Rectifier Tests

1. General

a. Tests shall be performed on all rectifiers per IEEE 1653.2.

b. Tests shall be performed prior to connecting line side ac system cables and 1000V main dc switchgear bus.

c. Tests shall be performed with diode bridges shorted and 164 Device Relay and 180 Device Diode Monitoring Circuits disconnected from the rectifier.

2. Resistance tests shall be performed in accordance with the following:

a. Using a low-resistance ohmmeter, check resistance of each bolted connection of each rectifier phase to main dc bus.

b. For each rectifier tested, if the resistance of any phase differs by more than 50 percent from the lowest value among diode bridge connections, take remedial measures to bring high value to within 50 percent of the lowest value, and retest.

3. High resistance grounding isolation tests shall be performed in accordance with the following:

a. Prior to test, rectifier mounting connections for cracks or other deficiencies that would compromise high resistance grounding isolation.

b. Perform Isolation (megger) test at 2,500 volts for one minute between rectifier frame and ground to verify isolation from ground. DC switchgear shall be electrically disconnected from the rectifier at the dc switchgear isolation cabinet.

c. Measured isolation resistance shall be 1,000 MΩ, minimum.

d. Repeat isolation tests following completion of dielectric testing.

4. Dielectric Withstand Tests

a. During dielectric withstand tests, all diodes and diode stacks shall be jumpered together to maintain all diode stacks at the same potential.

b. Perform dielectric withstand tests at 5 kV DC for one minute on rectifier diode assembly, as one complete unit.

c. Ground low voltage indication circuits for test.

I. DC Switchgear Tests

1. General

a. Tests shall be performed on all 1000V DC circuit breakers and dc switchgear bus assemblies.

b. Tests shall be performed prior to connecting 1000V DC system cables, and with rectifier bus disconnected from dc switchgear bus.

c. Test shall be performed with 164 Device Relays disconnected from the dc switchgear.

2. Circuit Continuity Tests – Perform continuity checks to verify shunt leads, and all 1000V dc system fuses

3. Resistance Tests

a. Using a low-resistance ohmmeter, check resistance of all bolted bus connections and of closed circuit breaker contacts of each circuit breaker.

b. For each DC switchgear line-up tested, if the resistance of any connection differs by more than 50 percent from the lowest value among similar connections, take remedial measures to bring high value to within 50 percent of the lowest value, and retest.

4. Insulation resistance tests shall be performed in accordance with the following:

a. Perform insulation resistance (megger) tests at 2.5 kV for one minute at each circuit breaker pole with circuit breaker closed, and across open pole.

b. Measured insulation resistance shall be 1,000 MΩ, minimum.

c. Repeat insulation resistance tests following completion of dielectric testing.

5. High resistance grounding isolation tests shall be performed in accordance with the following:

a. Prior to conducting high resistance grounding isolation test, inspect dc switchgear mounting connections for cracks or other deficiencies that would compromise high resistance grounding isolation.

b. Isolation tests shall be conducted with all circuit breakers inserted in their switchgear cubicles and closed.

c. Perform isolation (megger) test at 5 kV DC for one minute between each switchgear cubicle frame and ground, and from each switchgear cubicle frame to the adjacent cubicle or rectifier frames, to verify isolation from ground.

d. Isolate one cubicle frame from the switchgear lineup and ground the rest of the switchgear lineup frame. Perform isolation test at 5 kV DC kV for one minute between isolated cubicle frame and ground. Repeat test for each cubicle frame.

e. Perform isolation test at 5 kV DC for one minute between dc switchgear negative bus and ground.

f. Measured isolation resistance for all tests shall be 1,000 MΩ, minimum.

J. High Resistance Flooring Tests

1. General

a. Perform tests on high resistance flooring installed in all District Furnished DC equipment houses.

b. Tests shall be done with following pre-requisites:

1) Insulated equipment not being tested to be grounded

2) DC house base properly grounded, with ground integrity previously verified by test

2. High resistance floor isolation tests shall be performed in accordance with the following:

a. Test high resistance floors at 5 kV dc for 1 minute using a 6-inch square (minimum) weighted test plate with meter connected between the test plate and the DC house structure ground. Apply a high conductivity saline solution, 2/3 water, 1/3 salt, between test plate and floor surface to ensure good electrical contact. Test locations shall be 24 inches apart covering the entire floor surface. Perimeter locations shall be within six inches of the edge. Minimum isolation resistance shall be 1,000 megohms, minimum.

b. Measured isolation resistance for all tests shall be 1,000 MΩ, minimum.

K. Liquid immersed type auxiliary power transformer tests shall be performed in accordance with the following:

1. Perform insulation-resistance tests per NETA recommendations (temperature corrected), winding-to-winding and windings-to-ground, utilizing a megohmmeter with test voltage output per manufacturer's recommendation. Test duration shall be 10 minutes with resistances tabulated at 30 seconds, 1 minute, and 10 minutes. Dielectric absorption ratio and polarization index shall be calculated.

2. Test insulation resistance for each bus, component, connecting supply, feeder, and control circuit.

3. Perform tests and adjustments for control and alarm functions.

4. Perform winding resistance test and ensure deviation is less than 0.5 percent from either the adjacent coils or the calculated ratio.

5. Verify that the tap changer is set at specified ratio.

6. Test continuity of each circuit.

L. 125V DC control power system tests shall be performed in accordance with the following:

1. Battery System Tests

   a. Verify all battery charger functions and alarms.

   b. Perform resistance measurements using battery internal resistance tester Verify that cell internal resistance values do not vary by more than 25 percent between identical cells that are in a fully charged state.

   c. Measure battery charger float and equalize voltages. Verify that values are in accordance with manufacturer's published data.

   d. Measure temperature of every sixth cell to determine average battery temperature. The test time or required current discharge shall be adjusted for the temperature of the battery.

   e. It shall be verified that all 34.5 kV ac and 1 kV dc circuit breakers are closed, then disconnect battery charger from batteries. Battery discharge shall supply following loads over 8 hours:

      1) Normal continuous demand of station ancillary loads.

      2) Open, close, and open again all 34.5 kV ac and 1 kV dc breakers after 8 hours.

   f. Measure each cell voltage and the battery terminal voltage at the beginning of the test, at least once during the test, and near the end of the test. Verify measured values are in accordance with manufacturer's published data.

M. Negative Grounding Device Tests shall be performed in accordance with the following:

1. General

   a. Perform tests on Negative Grounding Device.

   b. Prior to testing, verify that District approved NGD parameters are entered in the controller.

2. Negative bypass switch tests shall be performed in accordance with the following:

   a. Demonstrate that switch opens and closes properly, and that C02 bypass switch indication LED correctly indicates.

   b. Verify that switch operates in the absence of 125V dc control power.

c. Using voltage signal generator, show that switch blocking functions correctly:

1) A voltage of ≥ 20V dc between dc negative bus and ground bus shall inhibit switch closing.

2) A current of ≥ 20A through switch shall inhibit switch opening

3. Demonstrate that NGD operates in the absence of 125V dc control power.

4. Functional Tests: Using voltage signal generator, demonstrate proper function for following conditions:

a. Positive high current

b. Negative high current

c. Positive timed current

d. Negative timed current

N. C02 panel tests shall be performed in accordance with the following:

1. Test and verify the correct operation of all hard-wired and communication-based interfaces of the C02 panel with traction power equipment at the traction power facility, which is controlled and monitored by the C02 panel.

2. Verify correct function of monitoring and control functions for transformers, negative grounding device, disconnect switches, and traction power equipment in each AC and DC equipment houses at each traction power facility. Confirm data transfer performance between the CO2 PLC, operator and mimic panels, and field equipment. Test by operating equipment to generate contact closures at the IOMs, MPRs, IPRs and NGD. Current injection or application of test voltages to millivolt shunts may be used to confirm correct operation of protective devices.

3. Verify discrete inputs by observing the status change on the mimic panel and/or the C02 display panel as applicable. Discrete outputs to equipment shall be verified by observing equipment status change on the individual breaker display panels, the C02 mimic panel and C02 display panel as applicable.

4. Demonstrate correct performance of all C02 operator panel display functions, including current alarms screen, alarms history screen, current equipment status, and traction power facility and vicinity single line diagram (default screen).

5. Verify that hard-wired alarms for all equipment including the protective relays, CFCs and FOTs in the ETTC, AC and DC control power circuits, 125 V DC battery and charger system, HVAC equipment, fire alarm systems, intrusion detection systems, communication sub-systems, and access control system operate correctly and display correctly on the C02 panel display.

6. Verify correct function of real-time analog data generation (inputs from instrument transformers, transducers, IPRs, and MPRs. Confirm correct transmission over the Ethernet and the display on the C02 panel. Check and verify device calibration and analog outputs from the C02 PLC to the meters mounted on the C02 mimic panel. Confirm all data updates take less than or equal to 1 second between application of signal at field device and display on C02 panel meter.

O. Perform tests on C04 and CCA cabinets as specified in Contract Specifications Section 34 21 33, Traction Power Control, Monitoring and Display Panel, and Related Equipment Article 3.05.

P. Sectionalizing breaker blocking system (SBBS) tests shall be performed in accordance with the following:

1. Verify the proper operation of the communication links between the blocking master controller and blocking auxiliary controller, located in traction power facilities.

2. Confirm that correct data required by the blocking logic is received by the master controller from the auxiliary controller, and that permissive or blocking signals are correctly transmitted from the master controller to the auxiliary controller.

3. Verify the proper operation of the communication links between the master controller and similar master controllers used in the blocking system on the existing System.

4. Verify that correct data is received for the status of the traction power facilities on the existing System as required for the operation of the blocking logic provided under the Contract. Conversely verify the master controller(s) provided under the Contract is/are transmitting correct data for the status of the traction power facilities to existing traction power facilities on the existing System, as required for the operation of a similar blocking scheme on the System.

5. Conduct test to confirm the proper operation of the blocking on closing logic for all 34.5 kV sectionalizing circuit breakers.

6. Confirm the proper operation of all alarm functions and status indications of the 34.5 kV blocking scheme, their recording in the C02 PLC of the same traction power facility, and transmittal to the ICS & EBP workstations.

Q. VLAN and IP Address Verification

1. Confirm correct VLAN and IP Address configurations of all Ethernet enabled equipment.

2. Confirm ability to connect remotely and communicate with all Ethernet enabled equipment.

R. Miscellaneous tests shall be performed in accordance with the following:

1. Third party Utility Services to Traction Power Facility Sites – Verify the required services have been inspected and tested in accordance with the requirements specified herein and/or elsewhere in the Contract.

2. DC Power Supply System Tests: Perform tests on the 125 and 24 VDC systems in accordance with Section 34 21 40, DC Control Power System.

3. Validate 480V AC automatic transfer switch operation, check functions of all L0X and D0X panels, check L0X and D0X undervoltage indications.

4. LV Lighting and Receptacles Tests – Verify the operability of all lighting and receptacle circuits. Verify the lighting levels at ground level meets the specified requirements.

5. HVAC System Tests: Perform tests in accordance with Section 23 81 00, Unitary HVAC Equipment.

6. Sump Pump Tests: Perform tests in accordance with Section 22 14 29, Sump Pumps.

3.05 TRACTION POWER FACILITY FUNCTIONAL TESTS

A. General

1. All tested devices shall be clearly marked as to test date, test connections, and Tester ID.

2. Record all control, lighting, and HVAC circuit volts and amperes.

3. Prior to functional testing, the 35 kV and 1000V dc system cables connecting substation equipment shall be tested per requirements of Section 34 22 23, Traction Power Cables.

4. Fiber optic and LV control and indication cables shall be tested per the requirements specified in Section 27 13 01, Communication Cables, and Related Equipment, and Section 26 05 24, Low Voltage Wires and Cables, respectively.

5. Permanent electric utility service shall be available at each traction power facility being tested.

B. When testing of discrete equipment and cables is complete, only power circuits and bus connections internal to the traction power facility shall be connected. All bolted connections shall be torqued to manufacturer’s recommended torque, and torque marks applied to all bolted connections.

C. Perform resistance tests at each bolted equipment interface point joining bus connections or cable terminations. At each location tested, if the resistance of any connection differs by more than 50% from the lowest value among similar connections, take remedial measures to bring high value to within 50percent of the lowest value, and retest.

D. The insulation resistance tests and dielectric withstand field tests previously done on discrete equipment shall be repeated following connection of bus work and power circuits.

E. Following successful completion of insulation resistance tests and dielectric withstand tests, all control power, control, indication, and alarm circuits shall be connected.

F. Verify all relays are set per the approved coordination study and unless otherwise specified ensure the settings of relays (with identical functionality) are set the same.

G. At this time 38 kV cables connecting the IDS switches and the 34.5 kV switchgear and 2400V dc system cables connecting dc feeder cables to the contact rail or rectifier negative cables to track running rails shall not be connected. Functional testing shall be performed to verify correct control and protection device settings and operation of all circuits per Contract requirements, approved design and construction submittals, and approved coordination study, and shall include the following:

1. AC switchgear potential transformer output magnitude and polarity.

2. Rectifier-transformer unit phase sequence tests: Perform phase sequence tests, per IEEE C57.12.90. Record rectifier ac phase voltage magnitude and polarity, each phase, and rectifier dc voltage level and polarity, each diode leg.

3. Automatic reclosing circuits and equipment.

4. ETTS testing per Contract Specifications Section 34 21 35.

5. Connection of all sensing and protective devices, including potential and current transformers, per approved coordination study.

6. Operation of all protective devices to prove correct control interfacing.

7. All telephone, access control, radio system, intrusion detection, and CCTV system local and remote functions.

8. Verification of HVAC equipment and lights. Record all HVAC and lighting circuits volts and amperes.

9. Assist District to verify IPR, MPR, NGD, and other data capable of transmission over the Maintenance VLAN can be successfully accessed at District maintenance VLAN workstations.

10. Ensure the test procedure clearly delineates which tests can be done safely post energization; simulated safely post energization; and need to be undertaken before energization for safety reasons.

H. Functional testing shall be performed to verify the following requirements:

1. Removal of control power source on one AC circuit breaker does not inadvertently trip another AC circuit breaker thereby interrupting 34.5 kV sub-transmission system and associated power supply to the tractive electrical load.

2. Removal and subsequent replacement of an IPR for an AC circuit breaker does not inadvertently trip another AC circuit breaker as its own IPR shall be protecting it.

3. Opening each rectifier door under energized condition will result in tripping and locking-out the associated Main and Tie AC circuit breakers and Main DC circuit breaker.

3.06 SYSTEM INTEGRATION TESTS

A. General Requirements

1. Permanent electric utility service shall be available at each traction power facility being tested.

2. Installation and associated punch list associated with the equipment under test shall be complete.

3. All train control system equipment shall be connected in its final operating configuration for the short circuit, ground fault, and train start tests.

4. Communications equipment and cabling that interfaces with the traction power facilities and equipment shall be successfully field tested per approved test procedures.

5. Transmission time for all control, indication, and alarm signals traveling between the facility C02 control panel and all field devices shall be less than 1 second.

6. Unless otherwise approved by the District conduct short circuit, ground fault and/or train start tests once all other tests specified herein and elsewhere in the Contract have been successfully completed, outstanding action items closed and test records have been submitted and approved.

7. Contractor shall clearly delineate pass / fail criteria and the means of interpreting test results in the test procedures for the short circuit, ground fault, and train start tests.

8. For short circuit test and ground fault tests the impedance bonds and rail connections shall stay connected and the train control equipment cable entrance racks shall be opened (i.e. cross connect links opened) so there is no feedback into the train control room and/or wayside cases.

9. For short circuit and ground fault tests the new contact rail system and running rail shall be physically and electrically disconnected from the existing system.

10. For the ground fault tests install a ground rod at least 6 feet clear of the contact rail system within the District's ROW adjacent to the test traction power facility.

11. Train start test shall be conducted with two ten (10) car trainsets loaded to AW2 load conditions or two twelve (12) car trainsets, as approved by the Engineer. and operated under ATO mode of operation. The test shall follow completion of all pre-requisite train control testing has been successfully completed.

B. Monitoring and control testing using OCC simulator laptop

1. The District will furnish a laptop computer to simulate the OCC ICS, EBP1, and EBP2 workstations. This is the laptop simulator used during factory testing.

2. To the extent practical all tests specified herein and the following Article 3.06C shall be done as end-to-end testing, actuating the signal from the end field device that generates that signal.

3. With the OCC simulator laptop computer connected to a C04 panel Ethernet switch verify:

a. That the C02 PLC communicates properly with the ICS and EBP workstations, the Operations Control Center (OCC), or both and all remote control commands from the ICS and EBP workstations, OCC, or both to local equipment are carried out correctly, and that all equipment status indications and alarms generated in the traction power facility are transmitted to the ICS and EBP workstations and OCC.

b. Proper operation of the C02 PLC with regards to logging of alarms and indications and their re-transmission to the ICS and EBP workstations.

c. Functional testing of each AC and DC circuit breaker in the test position to ensure a command instruction from the ICS, EBP, or both workstations will not operate a circuit breaker under energized state.

d. The output voltage at the rectifier, DC feeder circuit breakers, C02 display panel, and C02 analog voltmeter correlate, vary within acceptable tolerance or both, as defined by the equipment vendor(s).

e. Contractor-prepared detailed SCADA I/O schedules shall be used as the basis to document the results of each point test to verify system performance related to each SCADA I/O point. The I/O schedule shall include the internally (virtual) variables generated by the MPRs, IPRs, NGDs, TTCs, 34.5 kV blocking scheme equipment, and C02 PLC, such as transfer-tripping and emergency tripping events, software and hardware lockouts, breaker failure to close, 34.5 kV blocking systems alarms and indications, communication link failure. As each SCADA I/O point is tested, the Contractor shall verify the equipment status on the mimic annunciation panel (if applicable) and the point status on the C02's display panel, ICS and EBP workstations, and OCC and initial the associated entry on the field acceptance test I/O checklist.

C. Remote monitoring and control test: Following successful completion of testing using the OCC simulator laptop, tests shall be repeated in accordance with the following:

1. Verify that the C02 PLC communicates properly with the ICS and EBP workstations and/or the Operations Control Center (OCC), and all remote control commands from the ICS and EBP workstations and/or OCC to local equipment are carried out correctly, and that all equipment status indications and alarms generated in the traction power facility are transmitted to the ICS and EBP workstations and OCC, as required.

2. Verify the proper operation of the C02 PLC with regards to logging of alarms and indications and their re-transmission to the ICS and EBP workstations.

3. The operation of each circuit breaker shall also be verified by the operation of the control switches on the mimic panel, C02's Control and Annunciator Panel, ICS and EBP workstations and/or OCC.

4. Verify that equipment in the C04 panel communicates correctly with the BART maintenance computer network, and that data intended for this network such as real-time AC and DC currents and voltages, fault data traces of MPRs, IPRs, and NGDs, and diagnostic information is transmitted properly, and all related functions are in service and operate correctly. The manufacturer's MPR, NGD, and IPR monitoring software shall be loaded on a maintenance remote workstation to perform this test.

5. The Contractor-prepared detailed SCADA I/O schedules shall be used as the basis to document the results of each point test to test and verify system performance related to each SCADA I/O point. The I/O schedule shall include the internally (virtual) variables generated by the MPRs, IPRs, NGDs, TTCs, 34.5 kV blocking scheme equipment, and C02 PLC, such as transfer-tripping and emergency tripping events, software and hardware lockouts, breaker failure to close, 34.5 kV blocking system alarms and indications, communication link failure, etc. As each SCADA I/O point is tested, the Contractor shall verify the equipment status on the mimic annunciation panel (if applicable) and the point status on the C02's display panel, ICS and EBP workstations, and OCC and initial the associated entry on the field acceptance test I/O checklist.

D. Emergency transfer trip system testing shall be performed to prove system connectivity, performance, and response time for ETTS equipment, and confirm that it is properly installed and configured including redundant fiber-optic communications via loop connection of the serial ports of several ETTCs as shown on the Contract Drawings and approved design and construction submittals and in accordance with Section 34 21 35, Emergency and Transfer Trip System. Perform ETTS testing in accordance with Section 34 21 35, Emergency and Transfer Trip System Article 3.4. Field Testing.

E. Short Circuit Test shall be performed in accordance with the following:

1. For facilities installed within the existing system, short circuit, ground fault, train start, sound level testing, and infrared thermographic imaging will be done at the District's discretion following commissioning.

2. For the following system tests, the traction power facility 38 kV ac cables shall be connected to the 38 kV switchgear primary terminals and the IDS switches closed to provide 38 kV power the switchgear. The 1000V dc system feeder cables shall be connected to the 1000V positive feeder circuit breakers and contact rails and negative return system cables shall be connected to the rectifier negative buses, negative grounding device, and running rails as indicated on the Contract Drawings.

3. The short circuit test shall be performed on one traction power facility (cannot be Gap Breaker Station) to be determined by the District in coordination with the Contractor. All other traction power facilities shall be de-energized during this test, except for scenarios that require an adjacent traction power facility to be energized as defined below.

4. Do measurements specified below at facilities adjacent to the test that are supplying power for each test, up to a total of four (4) facilities. Facilities shall be chosen by the Engineer.

5. Contractor shall select and install appropriate recording instrumentation with adequate resolution, sensitivity, and recording speed to meet the following test objectives:

    a. Obtain data to calculate the specific inductance of the dc distribution system necessary to determine the rate-of-rise settings of the DC MPR.

    b. Verify the proper coordination and selectivity of the traction power facility protective relaying.

    c. Verify the fault clearing capability of the dc feeder breaker on the actual system.

    d. Check the proper operation of the transfer tripping, load measuring, and auto-reclosing functions of the DC MPR in conjunction with the ETTS. Demonstrate that the dc feeder breakers will not re-close on a sustained fault but will restore power to the contact rail system in case of a temporary fault. For these tests, the traction power facilities on both sides of the short circuit fault shall be energized.

    e. Include all relevant MPR current and voltage trace records in test report for comparison with test equipment data.

    Contractor shall clarify how a temporary and momentary fault condition will be achieved as part of the test procedure.

6. Contractor shall make a series of bolted short circuit faults between the contact rail and running rails by means of a short-circuiting switch or portable circuit breaker, at the following locations:

    a. Just outside the test traction power facility near dc cable to contact rail connection.

    b. 1600 feet away from the test traction power facility.

    c. 4000 feet away from the test traction power facility.

d. 7500-8000 feet away from the test traction power facility.

e. Where a Gap Breaker Station is located within the testing area, all circuit breakers shall be closed.

f. Adjacent traction power facilities to the test traction power facility shall be off-line.

7. The following parameters shall be monitored and automatically recorded in graphics format in the test traction power facility:

   a. DC bus voltage.

   b. Voltage across the breaker contacts.

   c. Traction power substation dc current.

   d. Traction power substation primary ac voltage.

   e. Traction power substation primary ac current.

8. The short circuit faults shall be cleared by the substation protective relays at their normal settings per the approved coordination study.

9. Following each short circuit test, all equipment including train control related hardware subjected to the short circuit currents, shall be inspected for possible damage. After the completion of the short-circuit tests, the Contractor shall perform the necessary maintenance on the circuit breakers, such as cleaning the contacts and arc chutes, to restore the equipment to its original condition.

10. Test data sheet shall clearly delineate whether the short circuit is maintained or temporary, and the condition after the short circuit (whether the faulted contact rail section(s) is/are isolated, or if there is successful re-energization in the cases of temporary fault).

F. Ground Fault Test

1. This test shall be performed to demonstrate the ability of the protective relay system to detect and isolate ground faults, as required. The test shall be performed with two adjacent traction power facilities on either side of the simulated ground fault under energized conditions.

2. Instrumentation and monitored parameters shall be as in the short circuit test, with the additional requirement of recording the positive and negative bus voltages to ground.

3. The following ground faults shall be made:

   a. Positive bus to dc enclosure. This test may be done by connecting the load measuring resistor circuit to ground.

   b. Negative bus to dc enclosure.

c. Contact rail to ground fault near the monitored traction power facility. Include all relevant MPR current and voltage trace records in test report for comparison with test equipment data.

G. Train Start Test

1. The train start test shall be monitored from the test and adjacent traction power facilities to be determined by the Engineer. One or two traction power facilities shall be energized for this test, depending on the objectives of the test setup.

2. The testing shall be performed with one and two simultaneously accelerating trains and shall include several locations for each scenario. The exact locations, direction of traffic, number of train starts, and length of train runs for this test series will be determined by the Engineer, in coordination with the Contractor.

3. Contractor shall select and install appropriate recording instrumentation to meet the following test objectives:

   a. Obtain load current parameters necessary to determine (in conjunction with the short circuit test data) the rate-of-rise settings of the DC MPR. Confirm that such settings do not result in nuisance trips during train starts but will trip the dc feeder breaker in the event of a remote short circuit fault.

   b. Verify the voltage regulation characteristic of the transformer/rectifier unit. In this test scenario, the test traction power facility shall be operated with one transformer-rectifier unit loaded to at least 300 percent of the nominal rating. At 300 percent load and 34.5 kV primary voltage, the rectifier output voltage shall be 880 volts with a tolerance of plus or minus 15 volts.

   c. Verify, through measurements, that the ripple on the dc voltage at different load levels is within the theoretical limits.

   d. Include all relevant MPR current and voltage trace records in test report for comparison with test equipment data.

4. The following parameters shall be monitored and automatically recorded at the test and adjacent traction power facilities during the test:

   a. DC bus voltage.

   b. Traction power substation dc current.

   c. Feeder breaker dc current.

   d. Traction power substation ac voltage.

   e. Traction power substation ac power.

   f. Traction power substation ac power factor.

   g. Noise level inside the traction power substation.

   h. Noise level outside the traction power substation.

   i. Power factor on the 34.5 kV system.

H. Audible sound level test shall be performed in accordance with the following:

1. Verify the ambient sound level at each traction power facility site without trainset movement (i.e. under no-load conditions).

2. Verify that the sound generated from each traction power facility site does not exceed contract requirements with a) the maximum number of fully loaded trainsets (for normal operation) simultaneously accelerated to attain maximum permitted civil line speed (in designated test area); b) all traction power facilities normally connected to the contact rail system and c) the contact rail system configured per the approved design.

3. Refer to Section 34 21 01, General Requirements for the Traction Power System, for noise level criteria.

I. Infrared thermographic inspection shall be performed in accordance with the following:

1. Perform thermographic inspection, at each traction power facility, to check for manufacturing/installation flaws.

2. Inspection/test shall be undertaken a) after energizing and loading the equipment for a sufficient time to raise the equipment temperature to operating limits, and b) the maximum number of fully loaded trainsets for normal operation shall be in operation.

3. Submit dated and site specific digital image and video files with the test report in electronic format on a flash drive for each traction power facility.

3.07 COMMISSIONING

A. General

1. The Contractor shall provide all necessary field support to assist District commissioning of new traction power facilities following successful completion of equipment functional testing described herein. Commissioning will be done during weekends, including system non-revenue periods as described in Contract Specifications Section 01 11 00, Summary of Work.

B. Connection of 38 kV and 1000V Cables

1. Following approval of test reports and resolution of punch list items District will close the 38 kV IDS switches to energize the 38 kV switchgear, and rectifier-transformer units. Following an assessment period, the 1000V DC main circuit breakers will be closed to energize the switchgear DC main bus.

2. When District maintenance staff is satisfied that the equipment is functioning correctly and is ready for service District staff will terminate the 1000V DC system positive and negative cables at contact rail and track connection points to make the facility ready for service.

C. Emergency and Transfer Trip (ETTS) System function and indications.

1. The Contractor shall provide support to District staff as needed to terminate Platform Trip System connections at the train control room or other facility adjacent to the traction power facility being commissioned.

2. Following connection of all Platform Trip circuits, the Contractor shall assist as needed in conducting live tests of the Platform Trip System to verify correct system operation.

3. The Contractor shall provide support to District staff as needed to terminate Transfer Trip connections at GBS's adjacent to the traction power facility being commissioned.

4. Following connection of all Transfer Trip circuits, the Contractor shall assist as needed in conducting live tests of the Transfer Trip system to verify correct system operation.

5. Connection and testing of the transfer trip system circuits may occur at a time later than connection and testing of the Platform Trip System and Emergency Trip System circuits.

END OF SECTION 34 21 80

ATTACHMENT FOLLOWS

Attachment 34 21 80 – A

Date

Correspondence Number

Originator’s Name and Address

Recipient’s Name and Title

Subject: Test Record Certification

Dear

I hereby certify that:

- The tests included in this submittal were conducted in accordance with the approved test procedure(s).
- The attached test results are complete, accurately reflect the conditions and empirical data noted during the execution of the test, and have been back checked by the Test Director / Manager.
- The test results have been evaluated and the unit(s) under test met the acceptance criteria as set forth in the approved test procedure(s).
- There are no outstanding test discrepancies associated with the submitted test records.

Sincerely,

Name:

Title:

Contact Details:

Attachment 34 21 80 – B

Test Issues Tracking Log

ITEM #	DATE	REFERENCE DOCUMENTS	EQUIPMENT/ CABLE IDENTIFIER	ISSUE	LOCATION	RESPONSIBLE PARTY	RESPONSE	DISPOSITION AFTER RETEST/ REGRESSION TESTING	STATUS	DATE VERIFIED

Attachment 34 21 80 – C

Test Metrics Log

TEST DOCUMENTATION		SUBMITTAL STATUS				TEST STATUS			ISSUES		COMMENT
CATEGORY	DOCUMENT REFERENCE	SUBMITTED	IN REVIEW	APPROVED	REJECTED	PASSED	FAILED	RETEST/ REGRESSION	OPEN	CLOSED	

SECTION 34 22 23

TRACTION POWER CABLES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. 35 kV Power Cables

B. 35kV Cable Termination and Splice Kits

C. Spark Gap Assembly

D. DC Power Cables

E. Miscellaneous Materials

1.02 MEASUREMENT AND PAYMENT

Not Used

1.03 REFERENCE STANDARDS

A. Association of Edison Illuminating Companies (AEIC):

1. AEIC CS8 Specifications for Extruded Dielectric, Shielded Power Cables Rated 5 through 46 kV

B. American National Standards Institute (ANSI):

1. ANSI/ASC H35.1 Alloy and Temper Designation Systems for Aluminum

C. American Society for Testing and Materials (ASTM):

1. ASTM A153 Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

2. ASTM A167 Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip

3. ASTM A325 Specification for High-Strength Bolts for Structural Steel Joints

4. ASTM B3 Specification for Soft or Annealed Copper Wire

5. ASTM B8 Specification for Concentric-Lay-Stranded Copper Conductor, Hard, Medium-Hard, or Soft

6. ASTM B173 Specification for Rope-Lay-Stranded Copper Conductor Having Concentric-Stranded Members, for Electrical Conductors

7. ASTM B766 Specification for Electrodeposited Coatings of Cadmium

8. ASTM B496 Specification for Compact Round Concentric Lay-Stranded Copper Conductors

D. Insulated Cable Engineers Association (ICEA):

1. ICEA S-93-639 (NEMA WC-74) 5 – 46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy

2. ICEA S-94-649 Concentric Neutral Cables Rated 5 – 46 kV.

3. ICEA S-95-658 (NEMA-WC-70) Non-Shielded Power Cables, 2000 V or Less

4. ICEA S-96-659 (NEMA WC-71) Non-Shielded Cables Rated 2001 – 5000 Volts for Use in the Distribution of Electric Energy

5. ICEA S-97-682 Utility Shielded Power Cables Rated 5 – 46 kV

6. ICEA T-26-465 (NEMA WC-54) Guide to Frequency of Sampling Extruded Dielectric Power, Control, Instrumentation, and Portable Cables for Test

7. ICEA T-33-655 Guide for Low-Smoke, Halogen-Free (LSHF) Polymeric Cable Jackets

E. E. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE 48 Standard Test Procedures and Requirements for High-Voltage Alternating-Current Cable Terminations

2. IEEE 383 Type Test of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Systems

3. IEEE 400 Guide for Making High-Direct - Voltage Tests on Power Cable Systems in the Field

4. IEEE 404 Cable Joints for Use with Extruded Dielectric Cable Rated 5,000 Through 46,000 Volts, and Cable Joints for Use with Laminated Dielectric Cable Rated 2,500 Through 500,000 Volts

F. Department of Defense, Military Specifications (MIL):

1. MIL-P-23469/4 Pin-Rivet, Grooved, Round Head; Straight Shank, Multiple Locking Grooves, Aluminum Alloys, Corrosion-Resistant and Carbon Steels

G. National Electrical Manufacturers Association (NEMA)

1. NEMA WC-26 Bi-National Wire and Cable Packaging Standard

H. National Fire Protection Association (NFPA):

1. NFPA 130 Fixed Guideway Transit Systems

I. Underwriters Laboratories Inc. (UL):

1. UL 44 Rubber-Insulated Wires and Cables

2. UL 486A Wire Connectors and Soldering Lugs for use with Copper Conductors

3. UL 1072 Medium-Voltage Power Cables

4. UL 1685 Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables 1992

J. State of California

1. CEC California Electrical Code, CCR, Title 24, Part 3

1.04 SUBMITTALS

K. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples for submittal requirements and procedures.

L. Shop Drawings: Submit the following shop drawings:

1. Cable section details for materials and cable assembly construction no later than 60 days prior to start of cable manufacturing.

2. Installation details for the spark gap assembly and enclosure showing overall dimensions and clearances, backboard support details, mounting details, cable routing and outline dimensions and tolerances, installation details, splicing details, and grounding installation details.

3. Splices and cable terminations showing cross sections and installation details, no later than 60 days prior to scheduled ordering of these items.

4. Cable reel components and construction details.

M. Product Data: Submit data for power cables and associated materials and accessories such as splices, terminations, connectors, and fireproofing tape. Product data shall include product description and detailed technical specifications.

N. Samples:

1. Provide the following sample products after completion of first production lot of cables and materials:

a. Two foot sample of each cable size, type, and use for: 35 kV power cable, 5 kV dc feeder cable, contact rail termination cable assembly, expansion joint

shunt assembly, flex jumper cable assembly, and 2kV cable for the load measuring system.

b. Jumper connection block comprising of rosette with cover and lugs for 750 kcmil and 350 kcmil dc power cables.

c. Jumper and feeder cable identification nameplates, showing type, size, embossing and method of attachment.

d. A complete set of 35 kV cable splice kit.

e. A complete set of 35 kV cable termination kit.

f. A complete set of 5 kV cable splice kit.

g. Conduit sealing fittings/bushings for the 35 kV and 5 kV cables.

2. Samples shall be labeled with the following data: name of Manufacturer; cable type, size, voltage rating, insulation, and thickness; brand name; and, application and use.

3. Before submitting the samples, ensure that the product will be available in the quantities required for the Contract. No change or substitution will be permitted after submittal of the samples.

4. Products incorporated in the work shall match the approved samples.

O. Submit product test program plan, procedures, and reports in accordance with Section 01 45 24, Testing Program Requirements. Manufacturer shall certify factory design and production test reports indicating compliance of cables and accessories with referenced Standards and these Specifications.

P. Installation, Termination, Splicing and Testing Manuals:

1. Provide a detailed written narrative describing the installation, terminating methods, manufacturer recommended field testing procedures and maintenance instructions for the power cables to be furnished. Drawings, sketches, tabulation of pulling tensions, allowable bending radius descriptions, part numbers, and sources of all special tools, gauges, and handling equipment required shall be included in the manual. Manual format and contents shall conform to the requirements for Operation and Maintenance Manuals as defined in Section 01 78 23, Operation and Maintenance Data.

2. Draft versions of the manuals for the 35 kV and 5 kV cables shall be submitted for approval. Final versions of manuals shall be submitted 30 days after receipt of District's comments and not less than 60 days prior to start of cable installation.

3. The manual shall include at a minimum the following:

a. Site storage instructions including handling, and storage requirements for short and long term;

b. Installation equipment checklist, equipment set-up with diagram, illustrations, and sketches; and recommended lubricants for cable pulling during installation;

c. Physical limitations of the cables relevant to cable pulling, including maximum pulling tensions, and maximum sidewall pressure;

d. Cable pulling technique, cable training and bending methods and limits;

e. Cable terminations, splicing supports, and fireproofing;

f. Instrumentation and procedures for field testing after installation and splicing. The testing procedures shall include all relevant settings and parameters such as test voltages and duration of application. The manual shall also include the fail/pass criteria for each test and any remedial measures that may be appropriate should a test fail.

Q. Shipping, Packaging, and Marking Methods. Submit proposed procedures and methods for shipping, handling, unloading, and storing of power cables 60 days prior to first material shipment.

1. Power cables shall be packaged for arrival at the site undamaged by handling and weather.

2. Power cables shall be placed on non-returnable individual reels. Each reel shall contain only one continuous length of cable. Reels shall have drums with diameters of at least 12 times the outside diameter of the cable shipped thereon and shall be of substantial construction to withstand multiple handling in transit and in cable installation and outdoor storage. Each reel shall be constructed and packaged as a minimum requirement per NEMA WC26. Submit for approval a drawing of cable reel components and construction.

3. Reels shall have weather-resistant markings on both sides showing the purchase order number, reel number, weight, actual length, cable type, conductor type and size, number of conductors, ground wire size, voltage rating, and the appropriate UL labels. The numerals and letters shall be at least one inch high. Packing and shipping papers shall be identified with the information shown on reels. Each reel shall also be marked clearly “STAND REEL ON RIMS ONLY. DO NOT LAY ON SIDE”.

4. Power cables shall be handled so as to prevent damage to the jacket and insulation. The ends of the cable shall be hermetically sealed with heat shrinkable elastomeric cap to prevent dirt and moisture from entering the cables during storage, handling, and installation.

R. Submit cable lubricant manufacturer’s certification that lubricant is compatible with cable.

1.04 SUPPLIER QUALIFICATIONS

A. The Manufacturer of the power cables shall furnish a certification proving a minimum of five (5) years business experience in the supply and manufacture of the same type and rating of power cables being supplied.

B. The Manufacturer of power cables with EPR insulation shall provide certification that the insulating and semi-conducting compounds used in the cable construction are to be a major manufacturer's proven development of their own in-house formulation and mixture, with an established quality control program for all suppliers products used in the compound make-up.

C. Submit for District approval, a certificate of experience for each engineer, technician, splicer, and cable lug welder that will perform installation work. Experience cited for each shall include performance during the immediate past three years in splicing and terminating cables of the types specified herein. Certification for the 35 kV splicer and terminator shall be issued by the splice kit manufacturer and certification for welders shall be issued by the manufacturer of the exothermic welding materials or by an independent laboratory qualified to test this type of welding.

PART 2 – PRODUCTS

2.01 GENERAL

A. Power cables shall be suitable for operation in wet and dry locations including underground ducts, moisture and sunlight resistant, and rated for cable tray use.

2.02 35 KV AC POWER CABLES

A. General: 35 kV ac power cables shall consist of stranded copper conductors with a semi-conductive screen, ethylene-propylene rubber (EPR) insulation, an insulation screen, metallic shield, concentric neutral conductors, a polyester film, and an outer jacket. The cable insulation and semi-conductive screens shall be manufactured by a single pass triple tandem extrusion.

B. Ratings:

1. Voltage Rating: The voltage rating of the ac power cables shall be 35 kV, 133 percent insulation level.

2. Temperature Ratings: The cables shall be designed to operate at a maximum conductor temperature of 105 ºC for normal operation, 140 ºC under emergency overload conditions, and 250 ºC under short circuit conditions, in accordance with ICEA S-93-639 and UL 1072.

C. Conductors

1. Conductors shall be uncoated soft copper, concentric, round, compressed or compact, Class B strand per ASTM B8 or B496.

2. Electrical resistance values of conductors shall meet the requirements of ICEA S-93-639 (NEMA WC74).

3. Conductor size shall be 250 kcmil.

D. Conductor Screen

1. An extruded layer of black semi-conducting thermosetting compound shall be applied over the conductor. The material shall be compatible with the conductor metal and insulating compound and shall be uniformly and firmly bonded to the overlying insulation and be free stripping from the conductor. The screen shall have similar temperature coefficient of expansion as the EPR insulation.

2. The conductor screen shall comply with ICEA S-97-682.

E. Insulation

1. The insulation shall be EPR type and shall meet all the requirements of ICEA S- 93-639 (NEMA WC74) and AEIC CS8. The EPR compound shall meet the qualification tests specified in ICEA S-94-649 and ICEA S-97-682.

2. The insulation shall have an average thickness of 420 mils, based on 133 percent level in accordance with ICEA S-93-639. The minimum insulation thickness at any point of the cable shall not be less than 90 percent of the specified average thickness.

F. Insulation Screen

1. An extruded layer of black semi-conducting thermosetting compound shall be applied over the insulation. The material shall be compatible with the insulation and overlying metallic shield. The material shall be free stripping from the insulation. The outer surface of the insulation screen shall be marked to indicate that it is semi-conducting.

2. The non-metallic insulation screen shall comply with ICEA S-93-639.

G. Metallic Shield and Concentric Neutral Conductors

1. The insulation screen shall be covered with a helical wrap of uncoated copper tape. The minimum tape thickness shall be 5 mils, and tape shall be applied with nominal 12- 1/2 percent overlap.

2. A sufficient number of concentric neutral conductors shall be applied over the metallic tape so that the combined conductivity of the tape and wire shields shall be at least 33 percent of the conductivity of the phase conductor.

3. The concentric conductors shall be No. 14 or No. 12 AWG bare, uncoated copper. They shall be evenly spaced and helically applied over the copper tape with a lay of not more than 12 times the cable diameter measured over the concentric conductors.

H. Outer Jacket

1. Jacket thickness shall be in accordance with ICEA S-93-639.

2. The jacket shall be low smoke, zero halogen material in compliance with the requirements of ICEA T-33-655, UL 1685, and ICEA S-93-639.

3. A thin polyester film shall be provided between the jacket and the concentric neutral conductors.

I. The cable shall be certified as passing the flame test specified in IEEE Standard 383, Article 2.5, and UL 1072. Cable shall also pass the flame and smoke release test specified in UL 1685.

J. Markings. Cables shall be identified with continuous markings in accordance with UL 1072 and AEIC CS8, Label Requirements. The markings shall include the name of the manufacturer, type, voltage rating, insulation and thickness and year of manufacture on the surface of the jacket. The cable markings shall also include the label “Sunlight Resistant Type MV-105 for Cable Tray Use”. The identification shall remain legible for the life of the cable under normal conditions of operation.

2.03 35 KV CABLE TERMINATION AND SPLICE KITS

A. Termination kits shall meet Class 1 termination requirements and shall conform to the requirements of IEEE 48 and IEEE 383. The kits shall also meet the Cyclic Aging Test in accordance with IEEE 404. The kits shall consist, as a minimum, of heat-shrinkable stress control and outer non-tracking insulation tubings, a high relative permittivity stress relief mastic for insulation shield cutback treatment, a heat activated sealant for environmental sealing, and installation instructions. The kits shall accommodate any common form of cable shielding/construction without the need for special adapters or accessories and shall accommodate commercially available connectors.

B. 35 kV Cable Splicing Kits: Splices shall be either in-line or insulated splices that meet the requirements of IEEE 404.

1. In-line or Continuous Splicing: Splice kits shall be factory engineered kits containing all necessary components to reinstate primary cable insulation, metallic shielding and grounding systems and overall jacket to the equivalent of the cable itself. The splice kits shall be capable of properly splicing the specified 35 kV power cables. The kits shall be manufactured and tested in accordance with the requirements of IEEE 404, IEEE 383, and IEEE 48. The kits shall consist, as a minimum, of stress-control sleeve, splice insulating sleeve, abrasion-resistant outer jacketing sleeve, shielding braid and mesh, stress relief material, and auxiliary crimps. The splice kits shall be provided with the required cable splice copper connectors, approved by a nationally recognized testing laboratory for the applications, sized to fit the cables. Splices shall be suitable for continuous immersion in water.

2. Insulated Splicing: Splice kits shall be the same as the in-line splicing kits except that the metallic shielding and concentric neutral at each half of the splice joint

shall be provided with cable with adequate and compatible insulation for complete isolation and separation. The kits shall consist of all the materials and accessories provided with the in-line splicing except shielding braid and mesh.

C. Cable termination and splice kits shall contain all components required for a complete splice or termination. The kits shall be supplied with solderless connector grounding accessory kits designed to maintain solid contact with the cable shield, and shall include the solderless connectors and solder-blocked tinned copper braid sized to match the cable shield ampacity. Splicing and termination kits shall be of the heat shrink type, and completed splices and terminations shall provide insulation properties equivalent to the insulation class of the cable they connect. Cable accessories shall be suitable to withstand the high-pot field test voltages with the specified duration and magnitude.

D. Cable preparation kits shall also be furnished for use in 35 kV power cable termination and splicing preparations. The kits shall consist of solvent wipes, abrasive strip and instruction card.

E. Furnish tools and other accessories required for a complete installation of cables, termination kits, and splice kits.

F. Lugs shall be compression type, two-hole, long barrel, seamless, tin-plated copper, and listed per UL 486A

2.04 DC POWER CABLES

A. General

1. Ratings:

   a. Voltage Rating: Dc power cables shall be rated 5000 V dc, except for the high-voltage control power cable which shall be insulated for 2000 V dc minimum.

   b. Temperature Rating: The dc cables shall be designed to operate at a maximum conductor temperature of 90 ºC for normal operation, 130 ºC under emergency overload conditions, and 250 ºC under short circuit conditions, in accordance with ICEA S-96-659.

2. Markings: Cables shall be identified with continuous markings showing name of manufacturer, cable type, voltage rating, temperature rating, insulation type and thickness, and year of manufacture printed on the surface of the insulation. The identification shall be durable to the extent that it will remain legible for the life of the cable under normal conditions of operation.

3. Application: Use for dc power cables shall be as follows:

   a. Contact rail positive and negative return feeder cables - Positive feeder cables connect the dc feeder circuit breakers in the traction substations to the contact rail system, and the negative feeder cables connect the rectifier negative bus in the traction substations to the shunts at the running rails.

b. Negative Grounding Device (NGD) cables – Connect between NGD and rectifier negative bus, and between NGD and substation ground grid.

c. Contact rail jumper cables - used to connect adjacent sections of contact rail.

d. Contact rail termination cables - connect the rosette at which the feeder or jumper cables are terminated to the contact rail.

e. Contact rail shunt cables - used as jumper across contact rail expansion joints.

f. High-voltage control power cable - used in control circuits exposed to the 1000 V dc potential, such as connections of load measuring resistors and contactors, wiring on the high-voltage side of isolation transducers, and connections of the load measuring circuit in the gap breaker stations to the running rail.

B. Contact Rail Positive and Negative Return Feeder Cables, Contact Rail Jumper Cables, and NGD cables: The cables shall be non-shielded, jacketed, Ethylene Propylene Rubber (EPR) insulation suitable for installation in metal raceways, cable trays, metallic and non-metallic conduits, and underground ducts. The cables shall be suitable for operation at normal voltage levels varying between 750 to 1250 Vdc, with transient over-voltages of up to 3000 Vdc. The cables shall also sustain operation when subjected to a 720Hz ripple voltage with a magnitude of approximately 100V peak-to-trough superimposed on the average dc voltage. The cables shall be manufactured and tested in accordance with ICEA S-96-659 (NEMA WC71), AEIC CS8, UL 1072, ICEA T-33-655, IEEE-383, UL-1685, and ASTM B8.

1. Conductor: Conductor shall be 750 kcmil annealed uncoated copper, concentric, round, Class B stranding, conforming to ASTM B8.

2. Conductor Strand Shielding: An extruded semi-conducting thermosetting compound or tape shall be applied over the conductor in accordance with ICEA S-96-659. The material shall be compatible with the copper and insulating compound, uniformly and firmly bonded to the overlying insulation, and free stripping from the conductor. The shield shall have similar temperature coefficient of expansion as the EPR insulation.

3. Insulation: The EPR insulation compound shall be heat, moisture, flame, sunlight and ozone-resistant, corona resistant, and meet or exceed the electrical and physical characteristics specified in ICEA S-96-659. The cable shall have at least a 155-mil average insulation thickness. The minimum thickness at any point shall not be less than 90 percent of the average insulation thickness.

4. Jacket: The jacket shall be low smoke, zero halogen material in compliance with the requirements of ICEA T-33-655-1994 and UL-1685. In addition to the general requirement on marking, the cable shall be identified “LS” for low smoke in compliance with UL1685.

5. Cable Overall Diameter: The maximum overall diameter of the cable shall be 1.47 inches.

C. Contact Rail Termination Cables, and Contact Rail Shunt Cables: The cables shall be manufactured and tested in accordance with the requirements of ICEA S-96-659 (NEMA WC71), AEIC CS8, and UL 1072, as applicable to non-shielded single-conductor power cable. The cables shall conform to the following requirements:

1. Conductor Size: Contact rail termination cables shall be 350 kcmil and contact rail shunt cables shall be 500 kcmil copper.

2. Stranding: Class H rope lay stranding in accordance with the requirements of ASTM B173.

3. Insulation: Insulation shall be ethylene-propylene rubber thermosetting compound (EPR), witjh the same properties as that specified for the feeder cables, rated for 5,000 volts minimum, with an average insulation thickness of 155 mils.

4. Jacket: The outer jacket shall be made of chlorosulfonated polyethylene (CSPE) material conforming to NEMA WC71 (ICEA S-96-659) and UL 1072.

5. Construction: The contact rail termination cables shall be 42 inches long and shall be provided with preassembled right angle terminal lug on one end. Contractor shall determine length of the contact rail shunt cables, and cables shall be furnished with factory-assembled lugs on both ends.

6. Flame Test. The finished cable shall be certified as passing the flame test specified in UL 1072.

D. High-Voltage Control Power Cable: The cable shall be non-shielded, jacketed, with EPR insulation. The cable shall have a 90 degrees C temperature rating and a voltage rating of at least 2000 V. The cable shall be manufactured and tested in conformance with NEMA WC70 (ICEA S-95-658) and UL44, and shall conform to the following requirements:

1. Conductors: Conductors shall be No. 6 AWG soft or annealed copper, concentric, round, Class B stranded.

2. Insulation: Insulation compound shall be EPR type, with average thickness not less than 70 mils. The minimum thickness at any point shall be not less than 90 percent of the average.

3. Jacket: The outer jacket shall be made of chlorosulfonated polyethylene material conforming to ICEA S-95-658.

4. Flame Test. The finished cable shall be sunlight resistant, suitable for installation in wet or dry locations, and shall be certified as passing the flame test specified in UL 44.

E. Cable Connection Assemblies: Cable connection assemblies shall be furnished for termination of contact rail termination and shunt cables.

1. Contact Rail Termination Cable Connection Assembly.

a. Contact rail connection plate shall be aluminum 6101-T6, dimensioned and drilled as indicated.

b. Lugs and Welding Molds: One end of flexible jumper cable shall be pre-assembled with right angle lug. Tinned copper lugs with two-hole NEMA type configuration and welding molds shall be the product of a standard manufacturer of exothermic welding materials. Welding shall be performed in strict conformance with the manufacturer's printed recommended procedures and instructions. The welding process shall not damage the tin coating on either surface of the outstanding leg of the lug.

c. Feeder and jumper cable connection blocks shall be designed to join 350 kcmil stranded cables to 750 kcmil stranded cables. Cable adapter shall be on one piece construction. Lugs for 350 kcmil and 750 kcmil cables shall be included with connection block. Connection block and cable lugs shall be as indicated.

d. Fasteners for connection of cable to contact rail connection plate: Bolts shall be 1/2 inch diameter, ASTM A325, Type 1, cadmium plated in accordance with ASTM B766. Locknuts and washers shall be ASTM A325, Type 1, cadmium plated in accordance with ASTM B766, sized to fit bolts.

2. Contact Rail Shunt Cable Connection Assembly. The assembly shall comply with the requirements specified for contact rail termination cable connection assemblies, except as follows:

a. Connection plate shall be aluminum 6061-T6, dimensioned and drilled as required.

b. The two ends of the shunt cable shall be pre-assembled with right angle lugs.

c. Shunt cable trough raceway, 6 inch fiberglass conduit, shall be provided in lengths as required.

d. The assembly shall consist of 7-500 kcmil cables.

F. DC Power Cable Accessories

1. Conduit Sealing Fittings/Bushings: After dc cable installation, conduits shall be sealed with bushings at each end. Bushings shall consist of slotted PVC coated steel discs, neoprene sealing ring, and stainless steel socket head cap screws and washers. The complete bushing assembly shall be provided with the appropriate number of holes to plug/seal the stub-ups while accommodating the size and number of cables which emerge from the conduit. Spare conduits shall be sealed with blank bushings without holes.

2. Terminal Lugs:

a. Provide compression type terminal lugs with two-hole NEMA type configuration for termination of the cables at the switchgear, at the NGD, and at the signal bonds on the tracks.

b. Load measuring cables shall be terminated using two-hole NEMA lugs on the DC switchgear side, and 3/8 inch plug terminals for bonding at the running rail side.

2.05 MISCELLANEOUS MATERIALS

A. Fireproofing Materials: Fireproofing materials shall be suitable for the voltage ratings specified for cables. The fireproofing tape shall consist of a flexible, conformable fabric having one side coated with a flame retardant, flexible, polymeric coating or a chlorinated elastomer not less than 0.050 inch thick or both, and shall weigh not less than 2.5 pounds per square yard. The tape shall be noncorrosive to cable sheath, shall be self-extinguishing, and shall not support combustion. The tape shall not deteriorate when subjected to oil, water, gases, salt water, sewage, and fungus.

B. Tie Wrap: Ultraviolet resistant nylon tie wrap, in sizes as required, with no metal parts shall be provided to tie feeder cables to support structures, to bundle the power cables, and where required for other uses.

C. Cable Lubricants: Cable lubricants shall be Polywater J manufactured by American Polywater, Slip X-300 manufactured by American Colloid, Wire Lube and Aqua Gel manufactured by Ideal Industries, or equal.

D. Cable Identification Tags: Non-metallic circular discs with two holes. System voltage, cable size, and feeder identification shall be stamped or embossed on each tag in characters of 1/4-inch minimum height. These ID tags shall be used on both ends of each traction power cable.

E. End Cap for Cables: End caps for cables shall be flame retardant heat Shrinkable manufactured by Raychem, Inc., Sigmaform Corporation, or equal. End caps shall be used for temporary sealing of cable ends.

F. Raceways: Refer to Section 20 50 13, Raceways for Facility Services for required raceways and appurtenances.

G. Grounding Materials: Furnish grounding materials in accordance with Section 26 05 26, Grounding and Bonding for Electrical Systems.

H. Cable Racks, Channel Inserts, and Supports: Cable racks, supports, and fasteners shall be furnished in accordance with Section 20 50 13, Raceways for Facility Services .

I. Cable Insulators for Installation on Racks or Channels: Porcelain with a minimum of two inches of bearing surface in the direction parallel to the cable.

J. Sealing Fittings for 35 kV Cables: Conduits for 35 kV cables, including spare conduits shall be sealed with water-tight expandable type fittings.

PART 3 – EXECUTION

3.01 INSTALLATION

A. General:

1. Cables shall be installed in raceways. Cable installation shall be in accordance with the recommended procedures by the cable manufacturers on cable installation, cable pulling, and sidewall pressure calculations and methods.

2. Cable Pulling:

   a. Manholes, splice and pull boxes, and conduits shall be thoroughly cleaned, dried, and free from debris prior to cable pulling. Pull wire brush, swab, and mandrel through conduit in a manner which will remove extraneous matter. Install pulleys on pulling irons where provided, otherwise temporary blocking and pulleys shall be installed and confirmed.

   b. Cables shall be pulled in the direction that exerts the least tension on the cables. Cables shall be pulled only in one direction. Pull cable directly into raceway from coils or reels. Multiple cables in the same conduit/duct shall be pulled at the same time. Do not install cable which has been laid on dirt. Do not pull cable with its end open. Maintain rubber tape on cable ends. Use cable lubricants where necessary.

   c. If cable has been pulled by pulling grips, remove damaged cable ends as soon as cable has been installed.

   d. Seal ends of installed cable with heat shrinkable end caps to prevent entry of moisture.

   e. Identify ends of cable before making connections or terminations.

   f. Terminate each end of conduit with sealing bushing. Ensure that sealing bushing holds cable against movement in both directions, and makes a watertight seal.

   g. Tie wrap power cables after installation.

3. Pulling Equipment and Pulling Tension: Contractor shall have suitable pulling equipment on hand that is confirmed to be in good working order. A dynamometer shall be used to measure the pulling tensions. Values obtained shall be recorded and incorporated into the Cable Test Report. The cable manufacturer's recommended maximum pulling tension and sidewall pressure values shall not be exceeded during cable pulling.

4. Cable Splices: Splices shall be suitable for continuous immersion in water and shall only be made in splice boxes or manholes. The splices shall be installed in accordance with the splice kit manufacturer's recommended installation procedures.

5. Cable Supports:

    a. Cables shall be routed and supported in trenches, pullboxes, manholes, and switchgear cubicles as indicated.

    b. As a minimum, cables in manholes shall be supported at 4-foot maximum intervals with support cradles, saddles, or cable trays.

    c. Cables in concrete trenches under the substations and gap breaker stations shall be installed and supported by fiberglass cable trays.

    d. Cables entering the top of switchgear equipment in substations or gap breaker stations shall be supported by cable trays or conduits.

    e. Cables entering the switchgear cubicles from the bottom shall be supported by cable support terminators or with basket-type cable grips of the type that utilizes support rings. Cables entering 1000V dc switchgear cubicles shall be supported as described in Section 34 21 25, DC Switchgear.

6. Cable Fireproofing: Dc positive cables and 35 kV power cables routed through substation and gap breaker station trench cable trays, manholes, pullboxes, or chases shall be fireproofed as follows:

    a. Strips of fireproofing tape approximately 1/16 inch thick by 3 inches wide shall be wrapped tightly around each cable spirally in half-lapped wrapping, or in two butt-joined wrappings with the second wrapping covering the joints in the first. For manholes and pull boxes, the tape shall be applied with the coated side toward the cable and shall extend one inch into the ducts. To prevent unravelling, the fireproofing tape shall be random wrapped the entire length of the fireproofing with pressure sensitive glass cloth tape.

    b. Spliced cables shall be fireproofed in accordance with the paragraph above, except with fireproofing extending only two feet beyond the spliced area on each end. Irregularities of the cable, such as at splices, shall be evened out with insulation putty before the tape is applied.

7. Cable Identification: Cable identification tag shall be affixed to each cable at each entry to and exit from each manhole, pullbox, trench, and switchgear assembly.

8. Cable Terminations: Terminations shall be installed using materials and methods as indicated or specified herein. Terminations shall be installed per the written instructions of the cable manufacturer and the termination kit manufacturer.

9. Electrical Connectors: Tighten electrical connectors and terminals in accordance with the manufacturer’s published torque-tightening values. Where manufacturer’s torque requirements are not indicated, tighten connectors and terminals to comply with tightening toques specified in UL 486A.

B. 35 kV Power Cables

1. Cable Splices:

   a. In-Line or Continuous Splicing: Contractor shall splice conductor with copper connector, primary cable insulation, metallic shielding and grounding systems with solderless connector and solder-blocked tinned copper braid and overall jacket to the equivalent of the cable itself.

   b. Insulated Splicing: Contractor shall splice the conductor primary cable insulation, and overall jacket. The metallic shielding and concentric neutral conductors at the splice joint shall be left isolated and insulated and brought out at opposite end of the spliced assembly for connection to the spark gap assembly. The insulated splice shall be constructed such that the 15 minute withstand voltage across the sheath or shield isolation is 35 kV dc. The Contractor shall perform a withstand voltage test on a prototype insulated splice and submit report 60 days prior to start of first insulated splicing of cables.

2. Cables Installed in Splice Boxes: Splices on different phases/cables of a feeder shall be staggered so that there is no physical overlap between the splices. Should the splices overlap, barriers or separators between splices shall be provided. Splices shall be fireproofed.

3. The 35 kV cable minimum bending radius shall be 12 times cable outer diameter in manholes, raceways, and pull boxes. Deviation may be permitted for unusual installation conditions when approved by the Engineer.

4. Grounding: Concentric neutral conductors and the metallic shielding of each 35 kV power cable terminated at the switchgear end shall be grounded. Install and terminate the concentric neutral conductors and metallic shielding in accordance with the approved Contractor's installation details and Section 26 05 26, Grounding and Bonding for Electrical Systems.

5. After field testing, the connections of the 35 kV cable to the bus shall be furnished with isolating, corona-resistant, pre-formed removable boot conforming to standard industry practice.

C. DC Power Cables

1. Cables installed in the same raceway shall be of the same polarity.

2. The minimum bending radius for dc power cables shall be 12 times cable outer diameter unless otherwise indicated or approved by the Engineer.

3. Terminate power cables with compression lugs.

D. Contact Rail Shunt Cables:

1. Assemble shunt cable connection plates on contact rails using 3/4 inch aluminum pin bolts and collars.

2. Pull in shunt cables in the protective trough per approved design. No part of the cable shall rest on concrete, ballast, or ground.

3. Connect/terminate each end of each cable to connection plates using 1/2 inch bolts, washers, and nuts. Bolts, washers, and nuts shall be cadmium-plated in accordance with ASTM B766.

E. Contact Rail Termination Cables:

1. Assemble flexible jumper cable connection plates on contact rail using 3/4 inch aluminum pin bolts and collars.

2. Terminate 350 kcmil flexible jumper cable at connection plates.

3. Minimum ground clearance of flexible jumper cable shall be 2 inches.

3.02 TESTING

A. General. Testing shall be performed in accordance with Section 01 45 24, Testing Program Requirements.

B. Factory Testing:

1. 35 kV Power Cables

   a. Testing of completed cables shall be performed in accordance with ICEA S-93-639, ICEA S-94-649, ICEA S-97-682, and UL 1072. EPR compound qualification testing shall be in accordance with ICEA S-94-649 and ICEA S-97-682.

   b. Each reel of completed cable shall pass the partial discharge (corona) extinction level test per AEIC CS8.

   c. Production sampling tests in accordance with AEIC CS8 shall be performed on the cables.

2. 35 kV Termination and Splice Kits: Factory testing of termination and splice kits shall be performed in accordance with the requirements of IEEE 48 and IEEE 404. The design tests for qualifying terminations and splices shall be in accordance with the requirements of IEEE 383.

3. DC Power Cables: Factory testing of completed cable shall be performed in accordance with NEMA WC71 (ICEA S-96-659) and UL 1072 for the 5 kV rated power cables; and in accordance with NEMA WC70 (ICEA S-95-658) and UL 44 for the 2 kV rated control power cables.

C. Field Testing - 35 kV Power Cables:

1. Insulation Resistance and Polarization Index Tests:

   a. Ground cable shields before doing insulation resistance and high potential tests.

b. Measure the cable insulation's resistance and polarization index following cable installation using insulation resistance tester (megohmmeter). The megohmmeter shall be battery powered, with selectable test voltage of up to 5000 V, feature full-scale range of not less than 20 Gohms, and shall have a built-in capability for direct measurement of the polarization index.

c. The insulation resistance (IR) shall be measured 1 minute after the application of the test voltage, while the polarization index (PI) shall be calculated from two time-resistance readings: one taken after 1 minute and the other taken 10 minutes from the start of the test. The temperature shall be recorded as well, and the measured insulation resistance shall be normalized to a base temperature of 20 degrees C. The IR and PI tests shall be performed using 5000 V test voltage.

d. The minimum acceptable insulation resistance and polarization index values shall be based on ICEA and cable manufacturer's recommendations, and shall be subject to the Engineer's approval.

e. Perform the IR and PI tests twice: first, after cable installation, but before splicing or terminating; and second, following the splicing and terminating, but prior to the high potential (hi-pot) test.

f. Carry out the IR and PI tests on each cable, with the test voltage applied between the phase conductor and grounded concentric neutral.

g. Prior to and after each test, discharge the cable capacitance.

h. Follow appropriate safety precautions during the tests, such as handling megohmmeter terminals and cable conductors through insulating gloves.

i. If the splicing or terminating is not performed immediately after cable installation, carry out another insulation resistance and polarization index tests just before splicing or terminating.

2. High Potential (Hi-Pot) Test:

a. Perform tests with a dc hi-pot tester specifically designed for the purpose, with overload or current-limiting devices to limit a possible short circuit current.

b. Test each cable installation after all splices are complete. No equipment shall be connected to the cable system during tests.

c. All cables shall be subjected to the high-voltage dc test of IEEE 400 modified as follows:

1) The final test voltage shall be 100 kV. Confirm that this test voltage and its duration are acceptable for the splices and terminations, by obtaining such assurance from the respective accessory manufacturer.

2) Raise the voltage gradually in 10-percent steps to 80 percent of the final, then in 5-percent steps to the 100-kV final level, which shall remain on for 15 minutes. Take current readings at each step after the current has stabilized. Plot the current readings on graph paper. If insulation breakdown is indicated at any point during the test by a sudden increase

in current, discontinue the test; locate and remedy the problem and repeat the test from the beginning. If a second breakdown is indicated, replace the cable at no additional cost to the District.

3. Shield Ground Test: Perform a shield-to-ground test with a megohmmeter using 1000 test voltage. Disconnect shield grounds at the equipment terminations prior to the test. Take jacket resistance readings between the equipment ground bus (or ground terminals) and the cable shield to confirm the integrity of the jacket, and that the shield is isolated from ground.

4. Conductivity Test at Splices and Terminations: Clean and polish cable conductor surface before the conductor is compressed into the cable termination lug or splice connector. After the compression and before the insulation system is installed, verify power circuit continuity by measuring the resistance of the connection using a battery operated digital low-resistance ohmmeter. Record and report the resistance value in the Cable Field Test Report. The electrical resistance of the connection shall not exceed 5 micro-ohms with 10 A test current applied, or shall meet the cable accessory manufacturer's recommendation.

D. Field Testing: 5 kV Power Cables:

1. Cables shall be attached to dc switchgear cable supports, but not terminated, prior to conducting insulation resistance and high potential tests.

2. Insulation Resistance and Polarization Index Tests: The tests shall be similar to that specified for the 35 kV power cables above, except that the 5000-volt test voltage shall be applied between conductor and ground.

3. High Potential Test: The tests shall be as specified for the 35 kV power cables above, except as follows:

   a. The final test voltage shall be 28 kV, and shall be applied between conductor and ground.

   b. The voltage shall be raised gradually in 10-percent steps to 80 percent of the final, then in 5-percent steps to 28 kV, which shall remain on for 15 minutes.

4. Conductivity Test at Splices and Terminations: The test shall be the same as specified for the 34.5 kV cables.

E. Cable Failure: If failure occurs on any specified field test, the Contractor shall correct the deficiency and retest. If the test fails again, the Contractor shall replace the entire cable segment at no extra cost to the District.

END OF SECTION 34 22 23

SECTION 34 24 13

CONTACT RAIL SYSTEM

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Contact rail assembly

B. Insulator assembly

C. Anchor assembly

D. Expansion joint assembly

E. Coverboard assembly

F. Miscellaneous materials

1.02 MEASUREMENT AND PAYMENT

Not used.

1.03 REFERENCES

A. General:

1. Submit certification that products furnished conform to the applicable reference standards and specified requirements. All design, materials, and testing shall be in compliance with the latest edition of referenced standards, codes and regulatory requirements.

2. Where any requirements of these Specifications are more stringent than the requirements of applicable laws, regulatory requirements, standards, or codes, the requirements indicated in these Specifications shall govern.

3. A certification or published specification data statement by a manufacturer listed as a member of the National Electrical Manufacturers Association (NEMA), to the effect that products conform to the specified NEMA standards, will be acceptable evidence that the products meet the requirements of these Standards.

B. American National Standards Institute:

1. ANSI B18.2.1 Square and Hex Bolts and Screws (Inch Series)

2. ANSI B18.2.2 Square and Hex Nuts (Inch Series)

3. ANSI B18.22.1 Plain Washers

4. ANSI C29.1 Test Methods for Electrical Power Insulators

5. ANSI C29.5 Wet-Process Porcelain Insulators - Low- and Medium-Voltage Types
6. ANSI C29.7 Wet-Process Porcelain Insulators - High-Voltage Line-Post Type
7. ANSI/ASC H35.1 Alloy and Temper Designation Systems for Aluminum

C. American Society for Testing and Materials:

1. ASTM A108 Specification for Steel Bars, Carbon, Cold-Finished, Standard Quality
2. ASTM A153 Specifications for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
3. ASTM A307 Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile
4. ASTM A313 Chromium-Nickel Stainless and Heat-Resisting Steel Spring Wire
5. ASTM A325 High-Strength Bolts for Structural Steel Joints
6. ASTM A36 Specifications for Structural Steel
7. ASTM A47 Ferritic Malleable Iron Castings
8. ASTM A536 Ductile Iron Castings
9. ASTM A563 Carbon and Alloy Steel Nuts
10. ASTM B117 Salt Spray (Fog) Testing
11. ASTM B134 Brass Wire
12. ASTM B633 Specification for Electroplated Coating of Zinc on Iron and Steel
13. ASTM B695 Coatings of Zinc Mechanically Deposited on Iron and Steel
14. ASTM D116 Vitrified Ceramic Materials for Electrical Applications
15. ASTM D149 Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
16. ASTM D1499 Operating Light- and Water-Exposure Apparatus (Carbon-Arc Type) for Exposure of Plastics
17. ASTM D2000 Rubber Products in Automotive Applications

18. ASTM D2240 Rubber Property - Durometer Hardness

19. ASTM D2303 Liquid-Contaminant, Inclined-Plane Tracking and Erosion of Insulating Materials

20. ASTM D256 Impact Resistance of Plastics and Electrical Insulating Materials

21. ASTM D2583 Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor

22. ASTM D3359 Standard Test Methods for Measuring Adhesion by Tape Test

23. ASTM D390 Specification for Coal-Tar Creosote for the Preservation Treatment of Piles, Poles, and Timbers of Marine, Land, and Fresh Water Use

24. ASTM D495 High-Voltage, Low-Current, Dry Arc Resistance of Solid Electric Insulation

25. ASTM D570 Water Absorption of Plastics

26. ASTM D638 Tensile Properties of Plastics

27. ASTM E84 Surface Burning Characteristics of Building Materials

28. ASTM E662 Specific Optical Density of Smoke Generated by Solid Materials

29. ASTM F436 Hardened Steel Washers

30. ASTM G152 Operation Open Flame Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials.

D. Industrial Fastener Institute:

1. IFI 100/107 Prevailing - Torque Type Steel Hex and Hex Flange Nuts Section F

E. Military Specifications:

1. MIL-P-23469/4 Pin-Rivet, Grooved, Round Head; Straight Shank, Multiple Locking Grooves, Aluminum Alloy, Corrosion-Resistant and Carbon Steel

F. National Fire Protection Association:

1. NFPA 130 Fixed Guideway Transit Systems

G. Society of Automotive Engineers:

1. SAE HS-1582 Manual on Design and Manufacture of Coned Disk Springs (Belleville Springs) and Spring Washers First Edition

H. Steel Structures Painting Council:

1. SSPC-SP6 Commercial Blast Cleaning

2. SSPC-SP10 Near-White Blast Cleaning

I. Boeing:

1. BSS 7239 Test method for toxic gas generation by materials on combustion

J. Bombardier:

1. SMP 800-C Toxic gas sampling and analytical procedures

K. Regulatory Requirements:

1. California Code of Regulations, Title 24, Part 2.

2. California Electrical Code, Title 24, Part 3.

3. Cal/OSHA Standards and California Electrical Safety Orders, Title 8.

4. Regulations of the California Public Utilities Commission, Rapid Transit District Safety Branch.

5. National Electrical Safety Code (NESC).

1.04 DEFINITIONS

A. Anchor Assembly: A longitudinal assembly of products including insulated anchor rods, clevises, spacers, anchor straps, mounting plates, and fasteners which retains the contact rail in the longitudinal direction and prevents transmission of longitudinal force to the insulators.

B. Contact Rail: A trackside conductor consisting of steel rail with aluminum bars attached on the webs, used to transmit electrical energy from power source to transit vehicle via current-collector shoes.

C. Contact Rail Assembly: The arrangement of products consisting of contact rail, splice bars and pin bolts, expansion joints, end approaches, dip rail sections, and fastening hardware.

D. Contact Rail System: The contact rail assembly, insulator assemblies, anchor assemblies, coverboard assemblies, and fastening hardware comprising the system used for the positive power source to the transit vehicle.

E. Coverboard Assembly: An arrangement of products including coverboard, support brackets and fasteners, which when installed, prevents accidental personnel contact with contact rail. The coverboard is used for supporting the train control wayside station stop and identification antennae.

F. Current Collector Shoe: The part of the current collector attached to the vehicle which rides along the top of the contact rail.

G. Dip Rail Section: A portion of contact rail at an elevation which allows the current-collector shoe in its lowest position to pass over it without contact.

H. End Approaches: Special sections of contact rail used at the ends of contact rail sections that ramp the collector shoe from one elevation in full contact to another elevation out of contact with the contact rail, or vice versa.

I. Expansion Joint: An assembly used in the contact rail to accommodate thermal expansion and contraction of the rail.

J. Expansion Joint Shunt Cables: Cables attached to the contact rail at each side of the expansion joint to provide electrical continuity across the expansion joint.

K. Feeder Cable: Electrical conductors which connect the traction power substations and gap breaker stations to the contact rail system.

L. Insulator Assembly: The porcelain insulator, base plate and “O” ring, rail clips, bolt, locknut and rail cushions comprising the assembly which supports the contact rail and insulates it from ground and structures.

M. Insulator Mounting Bracket: A device by which insulators are mounted on concrete ties.

N. Jumper Cable: Electrical conductor that electrically connects two sections of contact rail.

O. Splice Bars: Connect end approaches to the contact rail or connect two sections of contact rail.

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures and Section 01 33 23, Shop Drawings, Product Data, and Samples for submittal requirements and procedures.

B. Shop Drawings and Product Data: Submit shop drawings and product data for all hardware and materials comprising the assemblies and components of the contact rail system no later than 90 days before scheduled start of manufacturing. Submittals shall show the contact rail assembled as a system, and shall include calculations demonstrating conformance of the submitted design to the specifications. Shop drawings for all assemblies and components of the contact rail system shall include complete bill of materials. The bill of material tables shall have

a column for the BART inventory number. Contractor shall obtain the BART inventory number from the Engineer.

C. Samples and Mock-Up Demonstration: Perform a mock-up demonstration of the contact rail system products listed below to demonstrate conformance with specified requirements. The demonstration shall be at a location within 60 miles of BART Headquarters at 300 Lakeside Drive, Oakland, California.

1. Mock-up of contact rail products shall be prepared in accordance with the following assemblies:

    a. Contact rail with end approach attached

    b. Contact rail with dip rail ramp and dip section attached, mounted on both sizes of insulator assemblies with base plates attached to wood dunnage to simulate actual installation

    c. Contact rail with splice bars and pin bolts attached

    d. Contact rail with expansion joint attached

    e. Contact rail with coverboard attached

    f. Contact rail with anchor assembly attached, including spacer.

2. Unless specifically precluded, the Contractor shall demonstrate that the contact rail components are compatible and interchangeable with like components on the existing BART System by assembling the samples and BART's products into the six types of assemblies described in the mock-up installation described above.

3. During the mock-up demonstration, the Contractor shall demonstrate assembly and installation of the contact rail system including pin bolt installation as described in the Contact Rail System Installation and Assembly Manual.

4. Installation tools, equipment, and products used in the demonstration shall become the property of the District after the demonstration.

5. If demonstrations fail to indicate conformance with the specified requirements, the Engineer may require the Contractor to perform further testing or demonstrations at Contractor's expense.

D. Contact Rail System Installation and Assembly Manual:

1. The Contractor shall provide a detailed written narrative describing the installation and assembly procedure and maintenance instructions for the contact rail system products furnished, including all appurtenances supplied. Drawings, descriptions, part numbers, and sources of all special tools, gauges, and handling equipment required for assembly shall be provided. The Manual shall include procedures and recommendations for drilling holes for shunt and feeder connection plates and rail anchors and for cutting, bending, and drilling holes in the contact rail.

2. Draft versions of manuals shall be submitted for approval. Final versions of manuals shall be submitted 30 days after receipt of District's comments and not less than 60 days prior to start of contact rail installation.

3. Installation and assembly manual format and contents shall conform to the requirements for Operations and Maintenance Manuals as defined in Section 01 78 23, Operation and Maintenance Data.

E. Submit test program plan, procedures, and results prepared in accordance with Section 01 45 24, Testing Program Requirements. Submit expansion joint assembly installation data, prepared in accordance with Table 34 24 13 -1 herein, within 5 days after the data has been recorded.

F. Process Control Plan. Submit a process control plan for the coverboard and support bracket materials. The process control plan shall include a complete description of the process employed together with all parameters of the process and their allowable variations in producing the samples for qualification testing.

G. Steel Composition. Submit certification that the contact rail steel composition is in accordance with the specified requirements.

H. Shipping and Handling. Submit proposed procedures and methods for shipping, handling, loading, unloading, and storing of materials 60 days prior to first material shipment.

1.06 CONTRACT DRAWINGS

A. Contract Drawings represent basic arrangement, critical dimensions, and functional requirements, and are not intended to show all the elements required for the operation of the specified products. The Contractor shall develop the detailed design in conformance with the requirements shown on the Contract Drawings. The Contractor shall provide all elements necessary for the complete and functional installation of the products.

1.07 STANDARD PRODUCTS

A. Contact rail system components shall be proven standard products or equivalent to the products of manufacturers engaged in the production of such products for at least the past five years. Like components shall be supplied by a single manufacturer.

1.08 PRODUCT IDENTIFICATION

A. Contact Rail Identification: The name of the Manufacturer, the month and year of manufacture, and a BART part number identification shall be stamped on the aluminum clad surface. The hardware identification shall at all times coincide with its officially released engineering data. An eleven digit hardware identification numbering system will be provided by the District.

B. Identification of products other than contact rail shall be as follows:

1. Part Numbers

    a. Except fastening hardware and industry or government standard products, manufactured products shall be permanently marked with name, symbol, or other identification.

    b. Similar-appearing parts, not physically or functionally the same shall each be permanently marked, with the part number visible after product has been installed.

    c. Superseding parts shall be marked in the same manner as the parts they supersede.

    d. Parts marked with the same part number shall have the same functional and physical characteristics, shall be equivalent in performance and durability, and shall be interchangeable with no alteration to either themselves or to associated products.

    e. Parts shall not be marked for identification by color, color dots, or serial or modification numbers.

    f. Parts shall be marked to differentiate between old and new configurations by a part number change and shall be controlled by a new drawing number or a 3 dash number added to the original drawing number.

2. Lot Number

    a. Contractor shall ensure that part manufacturers develop a lot numbering and marking system that provides permanent lot identification and marking of parts for complete traceability to manufacturer’s lot records.

    b. A copy of lot records shall be attached to each shipment of products.

1.09 DELIVERY, HANDLING, STORAGE AND PROTECTION

A. Delivery, loading/unloading, handling, storage, and protection of contact rail products shall be in accordance with Section 01 60 00, Product Requirements.

B. Products shall be packaged for arrival at the site undamaged by handling and weather.

1. Temporary wood or steel braces, guides, skids, crates and other shipping devices necessary for transporting and temporary storage of the products shall be furnished.

2. Products shall be protected against corrosion, dampness, damage due to vibration, and any other damage during transportation and handling. All openings to the external environment shall be sealed before shipping. Products shall be packed in weather-resistant containers for storage outdoors.

C. The Contractor shall be responsible for and shall repair or replace products damaged due to shipping, handling, loading and unloading.

1.10 SPECIAL DEVICES

A. Furnish all special devices necessary for the handling and installation of the contact rail system components, such as lifting slings and bending devices.

PART 2 – PRODUCTS

2.01 GENERAL

A. Design: Contact rail system component parts shall be designed for a useful life expectancy of 25 years without refinishing or adding to the protective coating or finish. This design requirement establishes the standard of design, workmanship, and materials; it is not intended that Contractor extend the warranty beyond the period stated in the Contract, nor is it intended to be construed as imposing a warranty beyond that stated in the Contract.

B. Interchangeability:

1. It is not intended that products necessarily be identical to the ones on the existing BART system. Dimensional and performance criteria indicated shall govern. Unless precluded by requirements of the Contract Documents, the contact rail system components shall be interchangeable with like components on the existing system. The District will provide to the Contractor upon request any component of the existing contact rail system for compatibility and interchangeability design.

2. Like parts of duplicate units shall be interchangeable.

3. Units of the same rating and providing the same function shall be identical and interchangeable.

4. Component parts for each size of insulator shall be interchangeable with like components of like-size insulator assemblies existing on the BART System, as shown on the Contract Drawings. Rail clips, clip cushions, related bolts, and locknuts shall be interchangeable for use with any size insulator. Bases and base “O” ring cushions for insulators of all sizes shall be interchangeable.

C. Operating Environment: The contact rail system shall be suitable for operation in the specified environmental conditions. The contact rail system shall be completely operable with vehicle-mounted current collector speeds of 0 to 80 miles per hour, and in an environment containing contaminants normally found in electrified railway operations, including oils, metallic dust from wheels, rails and brake shoes, and dirt and mud from wheel splash.

D. Product Construction:

1. All products shall be made to American standard gauges.

2. The surfaces of the component parts shall be smooth, free of gaps, burrs, sharp edges, wrinkles, waves, and blemishes, and shall have uniformly rounded corners with constant radii.

2.02 CONTACT RAIL ASSEMBLY

A. Contact Rail Type A:

1. The contact rail shall be steel I beam rail not exceeding 75 pounds per yard, with a wearing surface of 1/2 inch minimum thickness with aluminum shapes attached to the webs. The aluminum shapes shall be attached to the webs either by pin bolts, or cast and rolled. The Contract Drawings show a contact rail, which is currently used in the existing BART system, with the aluminum bolted on the webs. The steel cross-section of the contact rail shall meet the dimensions for contact rail wear surface, height, width and base as shown on the Contract Drawings. The length of each contact rail section shall be 30 feet.

2. Steel Composition: Composition of the steel portion of the contact rail shall conform to the following requirements:

   a. The chemical composition of the steel section of the contact rail shall conform to the requirements of ASTM A36, or the chemical composition, in addition to iron, shall be as follows:

Constituent	Percent
Carbon	0.55-0.70
Copper	0.50 max.
Manganese	0.60-0.90
Phosphorus	0.04 max.
Silicon	0.10-0.35
Sulfur	0.05 max.

   b. Surface classification shall conform to the following: Rails which contain surface imperfections in such number or of such character which, in the judgment of Contractor and the Engineer will not render them unfit for recognized uses, will be accepted subject to the following requirements:

      1) Hot Marks: Hot marks such as shearing, scales, pits, guide marks, and hot scratches will be classified as follows:

a) Hot mark (except guide marks) that is not deeper than 0.010 inch will be accepted.

b) Guide mark in the head that is neither deeper than 0.010 inch nor wider than 0.062 inch will be accepted.

c) Not more than five percent of carbon steel rail may have defects deeper than the hot and guide marks described above, but not deeper than 0.020 inch.

d) Rail or portions of rails containing hot marks deeper than 0.020 inch will not be accepted.

e) If the depth of the hot mark cannot be determined by inspection, the area shall be probed with a grinder or magnaflux and, where necessary, a sample shall be sent to a metallurgical laboratory, for determination. If the area is determined to be acceptable, the ground area shall be cut out prior to shipment.

2) Longitudinal Cold Scratches: Longitudinal cold scratches (marks formed below 700 degrees F) will be classified as follows:

a) Rails containing a scratch not longer than 36 inches and not deeper than 0.010 inch will be accepted.

b) Rails containing a scratch deeper than 0.010 inch will not be accepted.

3) Transverse Cold Scratches: Transverse cold scratches (marks formed below 700 degrees F) will be classified as follows:

a) Rails containing a scratch that is not deeper than 0.008 inch will be accepted.

b) Rails containing a scratch that is deeper than 0.008 inch shall be either cut or scrapped.

4) Protrusions: Rail with protrusions not higher than 1/16 inch and not larger than 1/2 inch square shall not exceed three percent of the total tonnage.

c. Tolerances: The steel portion of the contact rail shall be straight within a tolerance of 3/8 inch maximum for 30-foot contact rail lengths. Twist tolerance of each length of contact rail section shall not exceed three degrees. The maximum vertical offset at any location on the contact surface shall not exceed 1/64 inch in one foot. Maximum sag with a 25-pound load at the midpoint between insulators spaced at ten feet shall be 1/64 inch. The rail ends shall be cut square and at right angles to the centerline of the rail with a variation in end squareness of not more than 1/32 inch. Standard rail lengths and tolerances shall be as indicated.

3. Aluminum Shapes: The aluminum shall conform to the Aluminum Association Standard ANSI/ASC H35.1 for a 6101-T6 alloy and temper designation for the pin bolted shapes and Aluminum Grade EC, 1350 Alloy with International Annealed Copper Standard (IACS) rating of 59.5 percent for the cast and rolled shapes.

4. Rail Fabrication:

    a. Cleaning and Grinding Steel: Steel portion shall be cleaned of rust and mill scale prior to assembly in accordance with and to the degree specified in SSPC-SP6 for Commercial Blast Cleaning, except that the head surface and surface of the steel to be mated with the aluminum shall be cleaned in accordance with and to the degree specified in SSPC-SP10 for Near-White Blast Cleaning. Head surface shall be further cleaned, if required, by grinding with a radial grinding wheel or stone to ensure no rust, mill scale, or surface irregularities remain.

    b. Application of Oxide Inhibitor and Lightweight Oil: Coat surface of steel shall be mated with aluminum with oxide inhibiting product immediately after cleaning. The oxide inhibiting paste shall be conductive and shall be compatible with aluminum to prevent iron oxide or rust re-forming on the steel rail, and prevent reformation of the aluminum oxide on the aluminum after cleaning. A coat of lightweight machine oil shall be applied to the steel as a preservative after aluminum extrusions have been attached. Product data sheets on the oxide inhibiting paste, including data on the shelf life, shall be submitted for District approval.

    c. Cleaning Aluminum and Application of Oxide Inhibitor: Just prior to mating aluminum to steel rail, the mating surfaces of the aluminum extrusions shall be cleaned of aluminum oxide using steel wool. The mating surfaces shall be liberally coated with the same oxide inhibiting paste used for the steel rail. The oxide paste shall be wire-brushed after coating. Coat mating surfaces immediately after cleaning, before rust or corrosion has started to form.

    d. Drilling of Steel and Aluminum: Holes shall be drilled in the web of the rail, perpendicular to the vertical and longitudinal axes of the rail. Locations of the holes shall be as indicated. Dimension and number of holes on the web to bolt the aluminum to the web shall be established by the Manufacturer, with a maximum spacing of 18 inches. At each end of each contact rail section, the holes shall not interfere with the splice joint holes and shall be located so as to prevent the aluminum from separating from the steel rail. Aluminum sections shall be deburred before assembly. Punching of steel rail and aluminum extrusions (in the case of bolted aluminum) shall not be permitted.

    e. Clamping: For contact rail with bolted aluminum extrusions, permanent aluminum pin bolts shall clamp together the metal components of the rail.

    f. Drilling of Splice Joint Holes: Contact rail sections, dip rail sections and end approaches shall be fabricated with holes for bolted joints. Splice holes shall be as indicated. Holes shall be deburred and edges shall be rounded and made smooth. For contact rail and dip rail sections, drilling of splice joint holes shall be performed after the aluminum is attached to the steel rail. Assembly shall then be completed by adding a coat of oxide inhibiting paste to the aluminum holes and end of rails before any moisture or foreign matter can contaminate the mating surfaces.

B. Contact Rail Type B:

1. The contact rail shall be stainless steel capped aluminum rail, and shall be comprised of a Grade 301L – quarter hard, or a Grade 304L – quarter hard stainless steel cap with a carbon content of not more than 0.03 percent, and a surface hardness of 230-250 Brinell, as measured by ASTM E10-14. Stainless steel cap shall have not less than 17 percent chromium content and not less than seven percent nickel content per ASTM A240, A666. Cap thickness shall be not less than 0.183 inch and not more than 0.240 inch. Cap shall be firmly locked in close faying contact with the top of a Grade 6101 aluminum conductor rail of minimum 7.5 square inches of cross sectional area. A layer of conductive grease in excess of quantity required to fill voids and crevices shall cover entire faying surface, leaving no gaps or crevices between steel and aluminum. Stainless steel cap shall be locked onto the aluminum rail by clamping the cap to the aluminum rail. Stainless steel locking tabs shall be inserted into the side slots in the aluminum rail, then welded to the stainless steel cap such that weld bead cooling and shrinking squeezes the stainless steel cap firmly to the aluminum rail. Alternative locking method of cam locking stainless cap with split aluminum rail cam sections bolted together is acceptable. Welds across the top center of the stainless steel cap and crimped on caps are not acceptable.

C. Electrical Properties:

1. Contact rail shall have electrical resistance not greater than 0.0020 ohms per 1,000 feet, at 20 degrees Centigrade. Resistance shall be measured across not less than 20 ft. of test section with one splice joint in the middle, using not less than 5,400 amperes.

2. Contact rail shall be capable of carrying 5,400 amperes continuous direct current, for a minimum of 30 minutes, without exceeding a temperature rise of 40 degrees Centigrade above 30 degrees Centigrade ambient in still air, with no benefit from cooling fans.

D. Mechanical and Physical Properties: Data specifying the mechanical and physical properties for the combined steel and aluminum contact rail shall be submitted.

E. Splice Bars: Splice bars shall be aluminum, sized mechanically and electrically to withstand overheating during short circuit conditions, and shall be flat to match flat aluminum web surface. The splice bar shall have adequate depth to meet the resistance and heat rise requirements. The splice bar holes shall be as indicated on the Contract Drawings and shall properly match with the holes in the rail ends. Aluminum for splice bars shall conform to the Aluminum Association Standard ANSI/ASC H35.1 for a 6101-T6 alloy and temper designation.

F. End Approaches: End approaches shall be precut at the angle indicated and holes predrilled at the factory in the pattern as indicated on the Contract Drawings. The cuts shall be square across the rail with a variation in end squareness of not more than 1/32 inch.

G. Dip Rail and Ramps: The top of the dip rail section shall be a minimum of three inches plus 1/8 inch or minus 0 inch below the upper surface of the contact rail. Dip rail ramps shall be provided with aluminum shapes on the web. The ends of each dip

rail ramp section shall be pre-cut and six holes pre-drilled at the factory as shown on the Contract Drawings.

H. Pin Bolts. Pin bolts for splice bars and for fastening aluminum shapes to the rail web shall be as specified below.

1. Pin bolts shall have standard round head. Collars shall be the flanged type. The collar shall be designed for installation by cold-swaging to the bolt with a tool which breaks away the bolt at the designed clamping force. The breakaway shall be a feature of the bolt and tool design and shall not require special skill or judgment on the part of the operator. Grip range shall include the full thickness of material to be clamped, with allowances for the type of collar specified. Bolt ratings shall be certified by the Manufacturer. The assembled bolt and collar shall not be subject to plastic deformation when used within certified ratings.

2. Pin bolts for splice bars and for fastening aluminum shapes to the rail web shall be 3/4-inch diameter, aluminum grade 2024 in accordance with the Aluminum Association Standard ANSI/ASC H35.1, swage-locking, round head, straight shank, multiple locking grooves, in accordance with MIL-P-23469/4. Pin bolt collars shall be aluminum, grade 6061 in accordance with the Aluminum Association Standard ANSI/ASC H35.1. Assembled bolts and collars shall have the following ratings: shear, 16,400 pounds; tensile, 17,700 pounds; and pre-load clamping force, 13,300 pounds.

3. Alternate pin bolts and collars for fastening aluminum shapes to the rail web shall be 5/8-inch diameter, ASTM designation A325, Type 1 steel, zinc-plated in accordance with ASTM B633, swage-locking, round head, straight shank, multiple locking grooves, in accordance with MIL-P-23469/4. Assembled bolts and collars shall have the following ratings: shear, 22,500 pounds; tensile, 27,100 pounds; and pre-load clamping force, 19,200 pounds. Washers shall be stainless steel, SAE THRU HARD type, sized to fit the pin bolt and shall have an outside diameter of 1-5/16 inches. Following the installation of the pin bolts, the break-off surface shall be touch-up galvanized using a zinc-rich primer that forms a dry film of at least 90 percent pure zinc.

2.03 INSULATOR ASSEMBLY

A. General: Insulator size designations refer to the height of insulator assemblies. The dimensions of insulators for designated sizes are shown on the Contract Drawings. The maximum tolerances on the dimensions of the insulator assembly components shall not exceed the design tolerances shown on the Contract Drawings. The insulator assembly with all components in place shall be designed to withstand without any damage or deformation a force of 4,000 pounds applied to a one-foot piece of contact rail mounted on top in the manner described herein for Qualification Testing, Insulator Assembly Strength Test.

B. Insulators: Contact rail support insulators shall be constructed of wet-process porcelain and shall conform to ANSI C29.5 and C29.7. Porcelain shall be sound, free from defects and thoroughly vitrified so that the glaze is not depended upon for insulation. The glaze shall be smooth, hard, and of a uniform shade of light gray conforming to ANSI Number 70; Munsell notation 5.0 BG 7.0/0.4. The glaze shall

completely cover all parts of the insulator which are exposed to contamination, except that the portion of the insulator making contact with the shim need not be glazed. The minimum creepage distance over the insulator external surface from the contact rail clamps to the insulator base fastener shall be eight inches. The insulator shall be suitable for contact rail system with operating voltage of up to 1,200 Volts dc and surge voltages of up to 3,000 Volts dc.

C. Base Plate and Rail Clips:

1. Base plates for securing the insulators to the foundation, and rail clips with cushions, bolts, and locknuts for attaching and securing the contact rail to the insulators shall be furnished as part of the insulator assembly as shown on the Contract Drawings. The rail clips shall allow free longitudinal movement of the contact rail assembly at any point in the contact rail system including at horizontal curves and at end ramps and dip rail sections located up to 400 feet away from an anchor assembly. Design the rail clips to allow such free longitudinal movement of the contact rail within a temperature range of -10 to +90 degrees C. The shape of the lower portion of the rail clip shall be such as to provide snug and secure fit around the head of the insulator when assembled with the neoprene cushion. The top of the rail clip shall not interfere with the extruded aluminum conductor or the splice bar.

2. Rail clips shall be either malleable iron conforming to ASTM A47, Grade 32510, or ductile iron conforming to ASTM A536, Grade 65-45-12. Bases shall be ductile iron conforming to ASTM A536, Grade 65-45-12. Rail clips and bases shall be hot-dip galvanized after fabrication, in accordance with ASTM A153.

D. Cushions and Base “O” Rings: Rail clip cushion shall cover the top, sides and dip into the bolt slot so that the cushion is between the rail clip and insulator. Cushions and base “O” rings shall be of the configuration indicated, neoprene in accordance with ASTM D2000, Specification 2BC415, and have a Durometer hardness between 65A and 75A for rail clip cushion and between 75A and 85A for base “O” ring in accordance with ASTM D2240.

E. Insulator Cantilever Bracket: Fabricate from extruded aluminum 6061-T6 alloy with dimensions as indicated on the Contract Drawings.

F. Spacer: In areas of direct fixation track construction the insulator assembly shall include a spacer with dimensions and installation requirements as indicated on the Contract Drawings. Material selected should have been used in similar or harsher environment and mechanical loading, and shall be submitted for District approval. The material shall be nonchip, noncreep, resistant to ultra-violet radiation, and shall provide a life cycle of no less than 30 years in actual operating environment. Submittals for the proposed material shall include physical properties with supporting test data that verifies the load bearing capabilities and resistance to creep, and verifiable installations of similar or more severe environmental and mechanical environment. The spacer material shall be either of the following two types:

1. Fiber-reinforced polymer composite, with reinforced fibers made of either glass, carbon, or aramid; and thermoset polymer resin, such as polyester, vinyl ester, or phenolic.

2. Epoxy grout, no less than 5000 psi; or grout with similar strength bonding agent. Material shall be premolded or fabricated into the spacer shape.

2.04 ANCHOR ASSEMBLY

A. Anchor Rods: The insulating material for the anchors shall be glass-reinforced polyester resin. The outer surface of the anchor rods shall be coated with a 1.5-mil film of light gray alkyd-type paint conforming to ANSI Number 70; Munsell notation 5.0 BG 7.0/0.4, resistant to weathering and tracking, and containing an ultraviolet inhibitor. The complete rod, including clevises, shall be rated at a minimum of 15,000 pounds in tension.

B. Clevises: Malleable iron conforming to ASTM A47; galvanized per ASTM A153.

C. Anchor Mounting Brackets, Anchor Strap, and Anchor Mounting Plates: Fabricate of steel conforming to ASTM A36 and shall be hot dipped galvanized after fabrication in accordance with ASTM A153.

2.05 EXPANSION JOINT ASSEMBLY

A. Expansion joints shall be designed to allow thermal longitudinal expansion and contraction of the contact rail. Expansion joints must accommodate rail movement due to contact rail temperature variations from -10 degrees C to +90 degrees C on a contact rail length of up to 400 feet, measured from an expansion joint to contact rail anchor. Prepare a tabulation for the required initial setting of the expansion joint gap as a function of the ambient temperature during installation. The maximum acceptable misalignment on curves, if any, shall be calculated along with the corresponding maximum distance to anchors and end ramps, considering the specified temperature range. This information shall be included in the field installation manual, and shall be used as basis for the contact rail installation design. The expansion joints shall provide a flat surface, uniform with the rails, to allow smooth passage of the collector shoe. Expansion joint assemblies shall be connected to adjacent contact rail sections using aluminum bolts as specified herein for contact rail splice bars. Submit certification demonstrating compliance of the expansion joint assembly design with the specified requirements.

B. Material: Cast ductile iron conforming to ASTM A536, Grade 65-45-12 or the same material as the contact rail steel.

C. The expansion joint shall require no lubricant under any operating conditions.

D. The expansion joint assembly shall include 6-foot contact rail sections, connection plates, and other components as indicated on the Contract Drawings, and shall be delivered fully assembled with factory-drilled holes ready for field installation. The 6-foot contact rail sections shall be attached to the expansion joint sliding parts by bolted connection as indicated, or cast and weld.

E. Quantity and size of shunt cables connecting the outer ends of the expansion joint assembly shall be 7-500 kcmil.

2.06 COVERBOARD ASSEMBLY

A. Coverboard: The coverboard shall be designed, fabricated, and tested to provide protection against electrical hazard from the contact rail assembly. Coverboards shall be capable of supporting a vertical load of 250 lbs at the midpoint between the end support brackets attached 10 feet apart without permanent deformation or fracture. Maximum deflection of coverboard under its own weight shall be 1/8 inch between support brackets.

1. Material: Coverboard material shall be reinforced polyester-resin fiberglass. Coverboard materials shall not propagate smoke or produce excessive smoke. Coverboard material strength and flammability characteristics shall be in accordance with NFPA 130, Section 6.4.2.5, and capable of passing the ASTM E662 test with a smoke emission optical density index (Ds) of 100 or less in four minutes.

2. Dimensions and Tolerances: The coverboard and bracket design shall provide the required clearances between the contact rail and the coverboard and brackets. These clearances, dimensions and tolerances as indicated on the Contract Drawings shall be maintained under normal use throughout the useful life of the coverboard assembly. Holes in the coverboard shall be drilled or punched in the factory prior to delivery. Coverboard thickness shall be uniform throughout its entire length.

3. Color: Color shall be light gray conforming to ANSI Number 70; Munsell notation 5.0 BG 7.0/0.4.

4. Treatment For Sunlight Protection: Coverboard surfaces exposed to sunlight, shall be treated with 2.0 mils dry film thickness coating of Sancryl 300 and Aqua-poxy-914 prime coat as manufactured by Sandstrom Product Company, or 2.0 mils dry film thickness coating of Sherwin Williams Polane S Plus, or approved equal. The material shall also contain an ultraviolet ray inhibitor to protect the coverboard substrate from ultraviolet ray degradation. The material shall be integrally manufactured into the surface. An alternative bonding technique conforming to the adhesion requirements of ASTM D3359 is acceptable subject to District approval. Contractor shall submit proposed material, method of bonding, and test procedures to demonstrate long-term performance and adhesion for District review and approval.

B. Support Brackets:

1. Material: The support brackets shall be manufactured of a non conductive, fire resisting material similar to the coverboard material. All support brackets shall be of the same material.

2. Support brackets shall be clamped directly on the contact rail with the clearance and tolerances indicated on the Contract Drawings. Brackets shall not encroach into the clearance envelope. Two types of brackets shall be furnished as shown on the Contract Drawings: standard fixed-height brackets and vertically adjustable brackets. The vertically adjustable brackets shall have the range of height adjustment as shown on the Contract Drawings for use with end

approaches and dip rail sections. The coverboard at end approaches and dip rail sections shall be maintained at the specified height above the top of the running rail by using the vertically adjustable support brackets.

3. Color. Support bracket shall be the same color as the coverboard.

2.07 MISCELLANEOUS MATERIALS

A. Hardware: The following requirements shall apply to bolts, nuts, and washers, as well as to metal fastening devices which are components of various assembly items indicated herein. Where high strength or HS is indicated, bolts shall meet ASTM A325, Type 1; nuts shall meet ASTM A563. Hardened washers shall be quenched and tempered in accordance with ASTM F436. Bolts and nuts not indicated as high strength or HS, and washers not indicated as hardened, may be carbon steel. High-strength bolts shall be marked “A325” or with three radial marks on heads. High-strength nuts shall be marked with three circumferential lines. Hardened washers shall be marked with three radial marks or shall have a blue or red coating.

1. Bolts shall conform to the dimensional requirements of ANSI B18.2.1 for Square and Hex Bolts and Screws. Bolts shall have hex heads unless otherwise indicated. High strength bolts shall have heavy hex heads. Threads shall be National Coarse (NC) unless otherwise indicated. Submit factory test reports in compliance with ASTM A325 Section 3.1.9 and Section 13.1 for certification.

2. Nuts shall conform to the dimensional requirements of ANSI B18.2.2 for Square and Hex Nuts. Nuts shall be hex unless otherwise specified. High-strength nuts shall be heavy hex. Threads shall be National Coarse (NC) unless otherwise indicated.

3. Self-Locking Nuts shall conform to the requirements of IFI 100/107 Section F. In addition to the requirements specified above for square and hex nuts, self-locking nuts shall have steel locking pin which travels between the threads during application to prevent backing off under vibration. These nuts shall be removable without damage and without damaging threads of the bolts, so they can be re-used.

4. Flat washers shall be steel, round and conform to the dimensional requirements of ANSI B18.22.1.

5. Coned Disk Spring washers shall conform to the requirements of SAE HS 1582, Commercial Grade. Rating or capacity shall mean the nominal load in pounds to flatten. Dish shall mean the distance to flatten. Coned Disk Spring washers shall be zinc-plated as specified for other metal fastenings. Proof of compliance with the rating or capacity shall be submitted.

6. Cotter Pins shall conform to the requirements of ASTM B134.

7. Fasteners for coverboard connections excluding locking devices shall be of nonconductive materials, weather resistant glass reinforced polycarbonate No. 3412 with ultra-violet stabilizer, or approved equal. Fasteners shall conform

to the requirements of ASTM D638 and shall have a minimum ultimate tensile strength of 8,000 pounds per square inch. Locking devices, such as easily removed hairpin cotters shall conform to ASTM A313 stainless steel, grade 304.

B. Insulator Shims: Shims shall be made of APA Grade C-C, plugged exterior-type plywood of the sizes indicated. All holes shall be drilled. Shims shall be pressure treated after fabrication with creosote preservative in accordance with ASTM D390 and D1760. Retention shall not be less than 0.6 pounds per cubic foot of wood. Pressure treatment shall be performed only by a firm regularly engaged in and licensed for such work. Insulator shims shall be provided in standard sizes of 1/2, 3/8, 1/4, and 1/8 inch thickness.

C. Fasteners for Securing Insulators, Insulator Cantilever Brackets, and Anchor Mounting Plates:

1. Hex Head Bolts: 5/8 inch diameter, 11 UNC, ASTM A307, Grade A, zinc-plated in accordance with ASTM B633, Class 5, Type III. Bolt lengths shall be sized in accordance with the following requirements:

    a. Bolts with length of shank and thread shall ensure thread engagement of 7/8 inch minimum for concrete tie installation, and 1-7/8 inch minimum for all other types of installation, such as second pour in a subway box, concrete decks of aerial structures, and at-grade slabs.

    b. Bolt thread shall extend 1/2 inch maximum beyond the nut in installations such as securing the insulator assembly to the cantilever bracket, or to insulator anchor mounting plate.

2. Hex Head Nuts and Lock and Flat Washers: ASTM A307, Grade A, zinc-plated in accordance with ASTM B633, Class 5, Type III.

D. Contact Rail Splice Shims: Shims shall be used for connection of contact rail with aluminum web to contact rail without aluminum web including that in the existing system. Shims shall be made of aluminum, grade 6101-T6, and shall conform to ANSI H35.1 alloy. Shape and dimension shall conform to contact rail designs, and where applicable, to the contact rail in the existing system. Contractor shall submit Shop Drawings for approval by the District.

E. Concrete Pedestals: Pedestals shall be cast-in-place concrete, Class 4000, with maximum 3/4 inch aggregate size. The same cast-in-place inserts specified herein for anchoring contact rail insulator assemblies shall be used.

F. Inserts for Anchoring Contact Rail Insulator Assemblies:

1. Except for concrete ties, inserts for all other applications shall be 2-1/2 inch long minimum, sized for 5/8 inch zinc-plated bolt, shall be made of ASTM A108 steel, zinc-plated on the inside in accordance with ASTM B633, and shall have allowable working tensile and shear loads of 2,000 and 2,500 pounds, respectively. The average ultimate tensile and shear loads shall be 8,000 and 10,000 pounds, respectively, on 4,000 psi concrete.

a. For inserts installed by the cast-in-place method or prefabricated in the resilient ties, the four inserts constituting an assembly shall be connected through hardened AWG No. 4 wires forming a welded cage, as shown on the Contract Drawings. The insert assembly shall be hot-dipped galvanized, with the inserts plugged, in accordance with ASTM A153, after being assembled and welded.

b. For inserts installed by the drill-and-grout method, the inserts shall be of the drop-in anchor type, and shall be hot-dipped galvanized on the outside.

2. Inserts for concrete cross ties shall be as shown on the Contract Drawings.

G. Connection Plates: Materials and dimensions for connection plates for contact rail termination cables and shunt cables shall be as shown on Contract Drawings.

H. Hardware for Anchor Assembly:

1. Hex Head Bolts: 5/8 inch diameter, 11 UNC; and 3/4 inch diameter, 10 UNC; both ASTM A325, Type 1, zinc-plated in accordance with ASTM B633. Bolt lengths shall be as required.

2. Hex Head Nuts: 5/8 inch and 3/4 inch diameter, self locking, HS, ASTM A325, zinc-plated in accordance with ASTM B633.

3. Lock Washers: ASTM A325, Type 1, hot dip galvanized in accordance with ASTM A153.

I. Coverboard Sealant: Matte Fever R910-G68, manufactured by Sandstrom Products, Port Byron, IL 61275, (309) 523-2121; Nuglas Plastic Refinisher, manufactured by Filon Division of Standard Oil Engineered Materials, Co., Hawthorne, CA 90250, (213) 757-5141, or equal. Sealant shall be compatible with the contact rail coverboard.

2.08 FINISH AND PLATING

A. Nuts, bolts and washers shall be zinc plated in accordance with ASTM B633, Class 5, Type III. All other ferrous metal hardware, other than stainless steel shall be hot-dipped galvanized in accordance with ASTM A153. Zinc plating shall be at least 0.0005 inch thick. Finish shall be natural on all items except high-strength flat washers, which shall be identified by a yellow chromate finish, unless otherwise indicated on the Contract Drawings. shall be submitted.

PART 3 – EXECUTION

3.01 INSTALLATION

A. General:

1. Contractor shall furnish all materials, including consumable items, tools, and equipment necessary to perform the contact rail installation work.

2. The contact rail system shall be connected to and interfaced with the existing BART contact rail system. The work at the interface shall include removing the end ramp sections of the existing contact rail system, drilling, grinding, cleaning and splicing the new and existing systems, and constructing new pedestals as necessary to provide for one completely integrated contact rail system.

3. Cutting: When making a field cut in existing or new contact rail, the rail shall be sawed square and at a right angle to the centerline of the rail with a variation in end squareness of not more than 1/32 inch.

4. Hole Drilling:

    a. Drilling of the contact rail shall be in accordance with the manufacturer's written instructions.

    b. Drill each hole in one continuous operation with a power drill. Drill holes perpendicular to vertical and horizontal axis of rail. Deburr holes. Do not ream holes.

5. Bending: Bending of the rail for curves shall be made in gradual steps using a suitable mechanical or hydraulic operated rail bender. Bending shall be performed in the presence of the Engineer.

6. Cleaning and Grinding Contact Rail:

    a. The contact rail to be installed and spliced shall be checked, inspected, and cleaned of rust or corrosion prior to installation. Prior to drilling and mating contact rail to aluminum splice bars, the mating surfaces portion of the contact rail (approximately within 1-1/2 feet from each end) shall be wire brushed in a manner which will remove adhering foreign materials, rust, or corrosion. The mating surfaces of the aluminum splice bars and contact rail shall be liberally coated with oxide inhibiting paste and then wire brushed through the oxide paste. Mating surfaces shall be coated immediately after cleaning. Wire brush contact rail using either an electric or pneumatic grinder having a wire brush attachment. Head surfaces for new and existing contact rail joints shall be further cleaned and aligned as required, by grinding with a radial grinding wheel or stone to ensure no rust, corrosion, or surface irregularities remain.

    b. Grinding the contact rail head of a straight section with a hand held electrical or pneumatic radial grinder and grinding stone to remove mill scale and surface irregularities will not be permitted.

7. Touch-up Galvanizing. Touch-up scratched or damaged galvanized surfaces after the installation of the contact rail system with zinc rich primer to form a dry film of at least 90 percent pure zinc.

B. Inserts for Anchoring Contact Rail Insulator Assemblies:

1. Concrete cross ties and resilient tie blocks shall be arranged to provide proper orientation and location of the inserts as required by the contact rail system layout drawings.

2. Field installed inserts for cantilever brackets for insulators spaced at the nominal 10 feet interval shall be cast-in-place; otherwise, inserts shall be installed by the drill and grout method.

3. Inserts for insulators mounted directly on the second pour concrete shall be installed by drill and grout method or cast-in-place.

4. The Contractor shall set-up a prototype installation for both the cast-in-place and drill and grout method of installation and shall test the insert assemblies to verify conformance with the specified ultimate tensile and shear loads. The test shall be performed prior to contact rail system installation in a Contractor designated laboratory or in the field.

C. Insulator Assembly:

1. Remove cap-plug from inserts cast into the concrete ties or the second pour concrete structures. Remove (blow out) contaminants from inserts by using compressed air. Cap-plugs in inserts where contact rail insulators have not been installed shall be left in place to protect the unused inserts.

2. In areas of direct fixation track, and in locations where more than two inches of height adjustment is required, a spacer shall be provided at the bottom of the insulator as shown on the Contract Drawings. Achieve final top of contact rail profile by shimming. Install plywood shim directly beneath insulators on all surfaces. Where spacers are used, the shim shall be installed between the spacer and the insulator base. Ensure insulator base plates, plywood shim and spacer surfaces are clean.

3. Install six inch insulators for dip rail section and approach ramps. Install nine inch insulators for all other contact rail sections.

4. Torque bolts in accordance with manufacturer’s recommendations. The torque shall be of sufficient force to clamp and avoid slippage of insulator base, shim and spacer, and avoid shearing of the bolts due to the mechanical forces resulting from the flow of short circuit current. Bolts shall be provided with lock washers.

5. Install insulators on ten foot centers. Do not exceed maximum allowable spacing of 10 feet 8 inches. At end approaches, install the last insulator at 18 inches from the end of rail.

6. No attachments of any kind shall be made to contact rail within seven inches of an insulator.

D. Contact Rail Assembly:

1. Allowable deviation of contact rail installation from indicated dimensions and positioning shall be:

   a. Total deviation of horizontal and vertical position of contact rail with respect to track alignment: plus or minus 1/8 inch.

b. Rate of change of deviation of horizontal and vertical position of contact rail with respect to track alignment: 1/8 inch in 30 feet.

c. Gap width between rail ends at splice bar locations: not more than 1/16 inch.

d. Difference in elevation of joined rails at expansion joints on contact surface shall be ground smooth at both rail to rail and rail to expansion joints.

e. Gap between rail ends due to temperature variation: plus or minus eight inches.

f. Vertical allowable clearance between the bottom of contact rail and top of cantilever bracket at dip section: not less than 3-1/4 inches.

g. Clearance between lowest end of end approach and any object: not less than six inches in every direction.

h. Contact rails shorter than 25 feet shall not be installed except as indicated or approved by the Engineer.

i. Tolerances shall not be cumulative except as accepted in writing from the Engineer.

2. Splice Bars: Just prior to mating aluminum splice bars to contact rail, the mating surfaces of the splice bars and the rails shall be cleaned of all foreign debris and aluminum oxide using wire brush. The mating surfaces shall be liberally coated with an oxide inhibiting paste and then wire brushed through the oxide paste. Mating surfaces shall be coated immediately after cleaning.

3. End Approaches:

   a. Assemble aluminum splice bar on rail.

   b. Set end approach in splice bar.

   c. Align top surface of rail and tighten collar to torque specified by pin bolt and collar manufacturer.

   d. Grind high rail head at joint to ensure smooth transition.

4. Dip Rail Sections:

   a. Assemble splice bars on each rail.

   b. Set the two ramp rail sections in their corresponding splice bars.

   c. Assemble splice bars on each end of ramp rail sections.

   d. Set the dipped sections between the two ramp rail sections in its splice bars.

   e. Align top surface of rail and tighten collars to torque specified by pin bolt and collar manufacturer.

   f. Grind high rail head at joint to ensure smooth transition. Limit grinding to 0.010 inch.

5. Anchor Assemblies:

a. Assembly procedure shall be in accordance with anchor assembly manufacturer's printed instructions.

b. Install anchor brackets and expansion joint assembly before connecting anchor rods to contact rail.

c. Connect anchor rods to anchor bracket.

d. Drill two holes in contact rail for connection of anchor rods as indicated.

e. Connect anchor rods to contact rail. Use spacers as indicated.

6. Expansion Joint Assemblies:

a. Record length of expansion joint gap, ambient temperature, date, and time of installation as indicated in Table 34 24 13-1 herein. Expansion joint gap shall be set in accordance with gap settings calculated as a function of ambient temperature during installation.

b. Install the expansion joint assembly in accordance with manufacturer's printed instructions.

c. Just prior to mating splices between the expansion joint and contact rail assembly, the mating surfaces shall be cleaned of all foreign debris and aluminum oxide using wire brush. The mating surfaces shall be liberally coated with an oxide inhibiting paste and then wire brushed through the oxide paste. Mating surfaces shall be coated immediately after cleaning.

7. Splice of Existing Contact Rail to New Contact Rail:

a. Prior to splicing, clean existing contact rail in accordance with the cleaning and grinding procedures specified herein.

b. Splice existing contact rail to new contact rail.

c. Assemble splice bars on each rail. Place shim as required to suit the shape of existing and new contact rail. Place compression fasteners.

d. Align top surface of rail and tighten collars to torque specified by pin bolt and collar manufacturer.

e. Grind high rail head of joint in a manner to ensure smooth transition.

f. Perform Alignment and Insulation Resistance Tests.

E. Coverboard Assembly: Install coverboard assembly only after insulator assembly and contact rail assembly have been installed and field testing has been completed.

1. Support Bracket:

a. Attach brackets to contact rail and fasten and torque bolts in accordance with manufacturer's printed installation instructions or 17 ft-lbf, whichever is less.

b. Install support brackets at intervals not greater than six feet and not less than 10.88 inches from an insulator, centerline to centerline. Ten foot long coverboard sections shall be supported by a minimum of three support

brackets, one at each end and one in the middle. Two support brackets are acceptable for coverboard sections six feet or shorter.

c. At dip rail and end approach sections, attach adjustable support brackets to contact rail and fasten and torque bolts in accordance with manufacturer's printed installation instruction or 17 ft-lbf, whichever is less. Determine the required height of adjustable bracket and torque adjusting bolts to 21 ft-lbf, ensuring that the assembly remains square. The Adjustable Bracket is at the proper height when the coverboard is level with the previous section.

2. Coverboard:

a. Minimum length of coverboard for installation shall be four feet long.

b. Coverboard shall extend not less than 12 inches but not more than 15 inches beyond the end of contact rail.

c. Attach coverboards to support brackets in accordance with the manufacturer's printed installation instructions and as shown on Contract Drawings. Depending on coverboard configuration, secure coverboard to bracket by inserting hairpin cotter pin in the appropriate hole of the coverboard pin for best fit. Use one washer minimum and up to one additional washer as a shim if necessary to achieve best fit. Coverboards shall not be allowed to rattle on the support bracket.

d. The coverboard sections shall be installed with overlap at the ends. The overlapping shall be arranged such that based on the normal direction of train travel the first coverboard shall be on top of the next coverboard.

e. Where cutting is required, cut coverboard ends square and straight.

f. Apply coverboard sealant to raw edges of field-sawn cuts as listed in Part 2.07.I.

3. Coverboards at Expansion Joints: Coverboard installation at expansion joints shall be in accordance with the installation manual.

F. Concrete Pedestals. Pedestals shall be set on stirrups embedded on the second pour concrete by drill and grout method.

G. Signage. Decals and warning signs shall be provided on the coverboard of the contact rail system as indicated. In locations where the train wayside antenna is mounted on the contact rail coverboard, the warning signs shall be located to avoid overlapping with the antenna.

3.02 TESTING

A. General:

1. Testing shall be performed in accordance with Section 01 45 24, Testing Program Requirements.

2. All tests shall be made on the same production runs from which deliveries under this Contract will be made.

3. Products which have been used for qualification testing shall not be included in quantities to be delivered unless permitted in writing by the District. Submit test certification with the test data showing that materials have passed all specified tests.

4. The Engineer reserves the right to witness any or all tests. Contractor shall inform the Engineer two weeks in advance of any test dates.

B. Factory Tests:

1. Contact Rail and Contact Rail Assembly Testing:

a. Qualification Testing.

1) Contact Rail Steel Mill Tests. Mill tests shall be performed and certified on steel portions of contact rail. Verify conformance with the steel composition specified herein.

2) Contact Rail Resistance Tests. A resistance test using 5,400 amperes of test current shall be performed on the steel contact rail with aluminum shapes attached to the web to demonstrate that the contact rail resistance meets the specified rating.

a) Section of Contact Rail: Middle 20 foot section of two 30-foot contact rail sections spliced together. Three test sections shall be tested.

b) Mounting of Test Section: Support the contact rail on electrical insulators spaced at 10 foot intervals.

c) Instrumentation: Digital voltmeter, accurate to +/- 10 microvolt shall be used, with its calibration certified by an accredited testing laboratory within the last year.

d) Procedure: Mount probes in a holding vise or jig, and apply them to the top steel surface of the contact rail in a manner which will ensure that ohmmeter probe spacing is accurate to within one percent of required spacing. Hand wire brush rail to ensure integrity of electrical connections.

e) Temperature: Sample the rail temperature at 5 equal spacings within the 10 foot test section using a Fluke temperature probe. The temperature shall be averaged and results noted on test data sheets. Measured rail resistance shall be corrected to 20 degree Centigrade.

f) Test Acceptance Criteria: If calculated resistance exceeds the specified rating, the contact rail design will be rejected.

3) Splice Bar Joint Resistance Test: A resistance test shall be performed on the contact rail in the splice bar joint area to demonstrate that the contact rail resistance across the jointed rail is equal to or less than the resistance of an equal length of unjointed rail at the same temperature. Tests shall be performed on three splice bar joints.

a) Test Section of Contact Rail With Splice Bars: Two 30-foot sections of contact rail shall be joined together with splice bars. Test the 20 foot section with splice bars centered. Three test sections shall be assembled and tested.

b) Mounting of Test Sections: Support the length of two contact rail sections on electrical insulators spaced at 10 foot intervals.

c) Test instrumentation, procedure, temperature measurement, and resistance calculation shall be as specified for Resistance Test for Contact Rail.

d) Test Acceptance Criteria: If calculated resistance of splice bar joint area exceeds the resistance of an equal length of unjointed rail, the splice bar design will be rejected.

4) Contact Rail Heat Rise Current Rating Test: Refer to Article 2.02.C.2.

a) Test Section of Contact Rail: The same three test sections, mounted in the same arrangement as specified for Resistance Test on Splice Bar Joints shall be used.

b) Instrumentation: Six thousand ampere power unit.

c) Test Connection: Thoroughly clean electrical contact area at each end of the test section using motorized wire brush, acetone and clean rags. Attach a connection plate to each end of the test section using three bolts tightened to maintain surface contact. Bolt power cables from the power unit to the connector plates on the test section.

d) Temperature: Attach thermocouples to test section using an epoxy bond. The thermocouples shall be connected to a Fluke Temperature monitoring system.

e) Procedure: At a stable ambient temperature, apply the test current to the test section and monitor the temperature. The temperature rise shall be recorded at 30-minute intervals until the contact rail temperature becomes stable.

f) Test Acceptance Criteria: If at any time during test the temperature rise exceeds the specified value, the test shall be concluded and the contact rail shall be rejected.

5) Contact Rail Corrosion Resistance Test: An accelerated salt spray corrosion test of 300 hours shall be performed, in conformance with ASTM B117. The test specimen shall be a five foot section cut from a contact rail section. The resistance between the aluminum and steel shall be measured before and after the corrosion tests with a Digital Low Resistance Ohmmeter as used in the Contact Rail Resistance Test. After the test, less than 2 percent of the contact surface between the aluminum, steel, and steel pin bolts shall show products of corrosion, and the resistance between the metals and collars shall not have increased.

6) Contact Rail Sag Test: Perform a sag (deflection) test by placing a 25 pound weight on top of a 30-foot section of rail supported by insulators spaced at nominal ten foot centers in accordance with the intended installation. The weight shall be placed midpoint between two insulators.

The actual amount of sag (deflection from horizontal) with and without the weight shall be noted on test report. If the sag is greater than 1/64 inches, the contact rail shall be rejected.

7) Contact Rail Mechanical Strength Test: The following mechanical strength test shall be performed on one 30-foot section of contact rail to demonstrate the integrity of the aluminum extrusion of the contact rail. Provide means to measure the distortion and deformation.

   a) A 30-foot section of contact rail shall be mounted on holding vise or jig and bent to a horizontal radius of 300 feet. The contact rail shall remain bent for 24 hours, at which time, the rail shall be removed from the holding apparatus and inspected. In the case of pin bolted aluminum, the aluminum shall not become loose from the contact rail. For cast and rolled aluminum, the inspection shall be performed using a magnifying glass. The aluminum shall not exhibit any abnormal splits, cracks, warps and delamination.

   b) For cast and rolled aluminum, five samples, each six inches in length, shall be cut from the contact rail tested. Each sample shall show the slot or hole at one end in order to examine the bonding of the aluminum to steel at the web interface and the flow of aluminum from one side of the web to the other via the slot or hole. The cast and rolled contact rail shall be deemed unacceptable if the aluminum exhibits splits, cracks, warps, delamination, and separation of the aluminum from the steel by more than 1/64 of an inch.

8) Expansion Joint Test: Tests shall be performed to demonstrate the expansion joint sliding and alignment capabilities. The expansion joint shall be installed between two contact rail sections.

   a) One or both sections of contact rail shall be arranged for sliding in and out of the expansion joint to simulate movement due to contact rail expansion and contraction.

   b) The top surface of the expansion joint shall remain flat and uniform with the adjacent rail, and shall allow smooth passage of a current collector shoe.

   c) Test Acceptance Criteria: If the prototype expansion joint fails to demonstrate its sliding and alignment capability, and its top surface compatibility with a current collector shoe, the prototype will be rejected.

b. Production Testing: The Contractor shall include the following test in its Quality Assurance Program.

   1) Resistance Test:

      a) Contact rail resistance test as specified above for qualification testing shall be performed on one rail section out of each 50 rail sections manufactured. Rail sections to be tested will be selected by the Engineer. Resistance test values shall be noted on test data sheets and will be evaluated to assure repetitive product conformity to design requirements.

b) Test Acceptance Criteria: If test results show a failure to achieve specified value, three rail sections of the 50 rail sections represented by the failure shall be tested. If a failure occurs on any of the three test sections, the entire production run represented by the 50 rail sections shall be rejected.

2) Tolerance Test: One contact rail section out of every 100 rail sections shall be tested to verify that the tolerances are within the requirements specified in Article 2.02-A.2.C herein, and as shown on the Standard Drawings. Rail sections to be tested will be selected by the Engineer.

2. Insulator and Insulator Assembly Testing:

a. Qualification Testing: Three glazed or three unglazed insulators as specified shall be tested of each size of insulator supplied.

1) Water Absorption Test on Unglazed Insulators: Sample insulators shall be tested per ASTM D116. Samples shall be dried at a temperature of 120 degrees C for at least 36 hours or until the weight of each piece is constant, and then weighed. The pieces shall then be immersed in water for 48 hours at a maintained temperature of 20 degrees C to 40 degrees C. Upon removal from the water, the surfaces shall be dried with a cotton towel and the pieces weighed. The increase in weight of any piece tested shall not exceed 0.2 percent.

2) Resistance Test on Glazed Insulators: Electrical contact on sample insulators shall be provided by a wet clay pad on the top and bottom of the insulator. The resistance shall be measured with a 2,500 volt motor operated megohmmeter, or other method approved by the Engineer. After 72 hours of immersion in water, all surfaces shall be dried, and the insulator shall demonstrate a resistance of not less than 8 megohms.

3) Dielectric Strength on Glazed Insulators: Sample Insulators shall be tested per ASTM D149. The same insulators used in the resistance test shall be used, again immersed in water for 72 hours, and all surfaces dried. Contact shall be made in the same manner as in the resistance test. The insulation shall not breakdown when 15,000 volts rms is applied for three minutes.

4) Dry Voltage Withstand Test on Glazed insulators: Sample insulators shall be tested per ANSI C29.1. A dry voltage test of 30 kV, 60 Hz, for one minute shall be performed.

5) Wet Voltage Withstand Test on Glazed Insulators: Sample insulators shall be tested per ANSI C29.1. A wet voltage test of 20 kV, 60 Hz, for 10 seconds shall be performed.

6) Mechanical Strength Test on Glazed Insulators: Sample insulators shall have a Drop Test performed as follows: An oak block with a cup to center the insulator shall be placed on a concrete foundation. The insulator shall be set directly on the centering cup. A malleable iron cap shall be placed on the top of the insulator. A disc of hardened steel 3/4 inch thick and of the same diameter as the cap shall be riveted to the cap. Between the insulator and the cap, a lead disc 1/4 inch thick or a canvas pad 1/16 inch thick shall be placed. The insulator shall be subjected to 10 blows of a

15 pound spherical iron weight dropped from a height of 36 inches. The insulator shall not crack, break or fracture.

7) Insulator Assembly Strength Test: Sample insulators assembled with spacer, shim, base plate and “O” Ring, rail clips, bolt, locknut and rail clip cushions and one foot of contact rail shall be mounted in manner specified for installation of contact rail and insulator assembly on direct fixation track. A lateral load test shall be performed to simulate the overturning force on the insulator assembly due to a contact rail short-circuit condition. The lateral force on the contact rail during short circuit condition is expected to be 4,000 pounds. Reject insulator assembly exhibiting values less than 4,000 pounds at failure, or exhibiting any signs of permanent deformation with a force of 4,000 pounds.

a) Test procedure: Apply lateral force to the contact rail side at its centerline, and symmetrical with respect to the insulator, at a 15 degree angle relative to the horizontal plane so that there is an upward component to the force. The force shall be increased in increments of 100 pounds until failure occurs.

b) Test Data: Make and maintain records of force at which failure occurs and descriptions of nature of failure.

b. Production Testing: The Contractor shall include the following tests in its Quality Assurance Program. One sample insulator from each kiln shall be tested.

1) Dry Voltage Withstand Test, as specified above for qualification testing.

2) Wet Voltage Withstand Test, as specified above for qualification testing.

3) Test Acceptance Criteria. If a sample insulator is cracked or fractured in the tests, the entire kiln represented by the sample shall be rejected.

3. Anchor Rod and Anchor Assembly Testing:

a. Qualification Testing: Sampling and conditioning procedures shall be as specified in the listed standard test methods, and recorded on certified test reports, as required. Where listed standard methods do not specify requirements, conditioning shall be at room temperature, and sampling shall consist of two specimens.

1) Water Absorption Test on Insulator Rod Material: Water absorption shall not be greater than 0.2 percent in 24 hours, when tested in accordance with ASTM D570.

2) Track Resistance Test on Insulator Rod Material: The time to track shall be 600 minutes minimum at 2,500 volts, when tested in accordance with ASTM D2303.

3) ARC Resistance Test on Insulator Rod Material: The time to failure shall not be less than 180 seconds, when tested in accordance with ASTM D495.

4) Dielectric Strength Test on Insulator Rod Material: Dielectric strength shall be 200 volts per mil of thickness minimum, when tested in accordance with ASTM D149.

5) IZOD Impact Strength Test on Insulator Rod Material: The average IZOD impact strength shall not be less than eight foot-pounds per inch of notch, when tested in accordance with ASTM D256, Method A. Each sample shall measure 1/4 inch wide and conform to Figure 4.

6) Anchor Assembly Tensile Strength Tests: The tensile strength of anchor rods and clevises within a temperature range of zero degrees to 100 degrees F shall not be less than 15,000 pounds when tested in accordance with ASTM D638. The Contractor shall report tensile strength at failure and describe the nature of the failure.

7) Test Acceptance Criteria: If tested anchor rods and clevises fail to satisfy test requirements, anchor rods and clevises shall be redesigned to correct cause of failure.

b. Production Testing: The Contractor shall include the following test in its Quality Assurance Program.

1) Tensile strength test, as specified above for qualification testing shall be performed on one anchor rod and clevises from each 100 supplied at a maximum of 15,000 pounds. The Contractor shall report tensile strength at failure, if failure is below 15,000 pounds, and describe the nature of the failure. Test data shall be evaluated to assure repetitive product conformity to design requirements.

2) Test Acceptance Criteria. If anchor rods and clevises fail to meet the 15,000 pound tensile test requirement, test three additional anchor rods and clevises from the lot of 100 represented by the failure. If another failure occurs, the entire production run will be rejected.

4. Coverboard and Coverboard Assembly Testing:

a. General: Tests shall be performed on the coverboard and support bracket material, and on the assembled coverboard and support brackets. A sample coverboard and support bracket material shall be specially manufactured to fit the respective tests. Test sample shall be of the same material and composition produced by the same manufacturing techniques and under the same process conditions but not necessarily of the same shape as the coverboard or support bracket. A lot, as used herein, is a group of coverboard or support brackets which have been manufactured in a continuous production run from one mix of homogenous raw materials and under identical process conditions. Coverboard, as used herein, shall mean the finished coverboard material with the surface treated with polyvinyl fluoride as specified.

b. Qualification Testing: The Contractor shall use its approved Process Control Plan in providing the samples for the qualification testing. Sampling and conditioning procedures shall be as specified in the listed standard test methods. Where listed standard methods do not so specify, conditioning shall be at room temperature (68 to 72 degrees F), and sampling shall consist of two specimens.

1) Weathering Test on Coverboard and Support Bracket Material: The total time for exposure shall be 2,000 hours but shall not exceed six months on samples tested in accordance with ASTM G152 and ASTM D1499.

ASTM G152 shall be followed with cycles of 102 minutes of light followed by 18 minutes of light and water spray. At the end of the exposure time, there shall be no visible evidence of deterioration such as warping, cracking, peeling, delamination, or any other defects.

2) Surface Burning Characteristic Test on Coverboard and Support Bracket Material: The Surface Burning Characteristic rating shall not be greater than 25 when tested in accordance with NFPA 255 (ASTM E84) and NFPA 130, Section 6.4.2.5.1.

3) Smoke Generation Test on Coverboard and Support Bracket Material: The smoke generation specific optical density, Ds, shall be determined by tests in accordance with the flaming and nonflaming modes of ASTM E662. The Ds values shall not exceed 50 within 90 seconds after the start of the test, and shall not exceed 50 within four minutes after the start of the test.

4) Toxicity Test on Coverboard and Support Brackets Material: When tested in accordance with either BSS 7239 (Boeing standard) or SMP 800-C (Bombardier standard), the toxic smoke gases when burned according to the ASTM E 662 test shall not exceed:

Gas Generation	Values (Maximun PPM)
Carbon Monoxide (CO)	1,000
Nitrogen Oxides (NOx)	100
Ammonia	2,500
Aldehydes	50
Hydogen Cyanide (HCN)	60
Hydrogen Chloride (HCL)	100

5) Water Absorption Test on Coverboard and Support Bracket Material. Water absorption shall not be greater than 0.3 percent in 24 hours, when tested in accordance with ASTM D570.

6) Track Resistance Test on Coverboard and Support Bracket Material. The time to track shall be 600 minutes minimum at 2,500 volts, when tested in accordance with ASTM D2303.

7) ARC Resistance Test on Coverboard and Support Bracket Material. The time to failure shall not be less than 180 seconds, when tested in accordance with ASTM D495.

8) Dielectric Strength Test on Coverboard and Support Bracket Material. Dielectric strength shall be 200 volts per mil minimum, when tested in accordance with ASTM D149.

9) IZOD Impact Strength Test on Coverboard and Support Bracket Material. The Average IZOD impact strength shall not be less than eight foot-pounds per inch of notch, when tested in accordance with

ASTM D256, Method A, Figure 4. Each sample shall measure 1/4 inch wide.

10) Mechanical Strength Tests on Coverboard and Support Brackets. The following mechanical strength tests shall be performed on an assembly of 30 feet of coverboard, seven brackets, the necessary coverboard pins, and a section of contact rail, set up as intended to be installed on the BART system. The Contractor shall provide means to measure the distortion and deflection.

    a) Vertical Load Cyclic Test: A 250 pound weight consisting of a sand bag or a similar object with a bottom surface 6 by 12 inches shall be placed at any point between two support brackets as selected by the Engineer. The weight shall remain in place for 30 seconds and then be removed for 60 seconds. This cycle shall be repeated 50 times. After this 50 cycle test, the coverboard and support bracket separately, shall be inspected with a 7-power magnifying glass and shall show no splits, cracks, peels, or breaks. The coverboard and support bracket separately, shall then be measured and shall not show any permanent distortion or deflection from original coverboard and support bracket configuration.

    b) Vertical Load Impact Test: The assembled bracket and coverboard shall be tested for vertical impact with a 250 pound weight dropped twice from a minimum height of 30 inches above the high point on the arch of the coverboard between brackets onto a 12 X 42-inch area of coverboard. Deflection may be one inch maximum with impact but the coverboard and bracket shall immediately return to its original configuration with no permanent distortion or deflection.

    c) Horizontal Impact Test: A 250 pound weight shall be suspended from a point eight feet directly above the leading edge of the coverboard at a bracket. The weight shall be held aside so that it will swing a distance of at least two feet and strike against the coverboard at the bracket. The length of the coverboard contacted by the weight shall not be greater than one foot. After impact, there shall be no permanent distortion or deflection.

11) Test Acceptance Criteria:

a) Material: If coverboard and support bracket material fails to satisfy test requirements, coverboard and support bracket material shall be redesigned to correct cause of failure.

b) Coverboard: If any of the tested coverboard fails to meet any of the requirements of the mechanical strength tests, one additional coverboard from the same lot shall be tested. If it fails, the entire lot of coverboard will be rejected by the Engineer.

c) Support Bracket Assembly: Tested brackets and clamps from the mechanical strength tests shall not show splits, cracks, breaks, or any other detrimental effects. If one bracket of a lot fails to meet specified requirements, three additional brackets from the same lot shall be tested. If any bracket fails to meet any of the requirements, the bracket shall be redesigned to correct the cause of failure.

c. Production Testing: The Contractor shall include the following tests in its Quality Assurance Program.

1) BARCOL Hardness Test: The test shall be performed on one coverboard and one support bracket from each lot produced.

a) The BARCOL Hardness Test shall be performed using a Barber Colman Company BARCOL Impressor. The BARCOL Hardness shall be obtained by direct reading of the dial indicator. The test shall be performed in an area as directed by the Engineer.

b) BARCOL Hardness Test Minimum Reading: The results of the BARCOL Hardness Test reading of cured finished sections shall be a minimum of 40 averaged, when tested in accordance with the requirements of ASTM D2583. Any coverboard or bracket failing to meet the minimum average requirement, the entire lot shall be rejected. However, if the product meets the requirements of the Vertical Load Cyclic Test, it shall take precedence and the lot shall be acceptable.

2) Support Bracket Assembly Torque Test: The test shall be performed on a random sample of one percent, but no less than three assemblies in each lot. The test shall be performed on a support bracket assembly and a minimum six inch section of contact rail set up a as intended to be installed on the BART system. Both 3/8 inch bolts shall be torqued to 25 ft-lbf. For testing purposes, Grade 5, Zinc-plated steel hardware may be used in place of stainless steel. Visible cracking or failure under loaded conditions of either the bracket or clamp, which remains visible after the loading is removed, shall constitute failure and cause rejection of the batch in which either the failed bracket or clamp had been manufactured. Exception: The entire lot may be tested 100 percent for compliance. Only those pieces of the lot that fail shall then be rejected.

3) Coverboard Pin IZOD Impact Strength Test: The test shall be performed on a random sample of one percent, but no less than three pins in each lot. The stem of the pin shall be held firmly in a vise or similar device. A force of 150 pounds shall be applied for five seconds to the head of the pin in a direction perpendicular to the stem. Thereafter, a prying force of 150 pounds shall be applied for five seconds to the head of the pin, in line with the axis of the stem. Cracking or fracture of one pin shall constitute failure and cause rejection of the batch in which the failed pin had been manufactured.

C. Field Tests:

1. General:

   a. Test installed contact rails in the presence of the Engineer.

   b. Perform visual inspection of all joints prior to performing field tests.

2. Contact Rail Electrical Resistance Test:

   a. Method: Ohmmeter measurement.

   b. Contact Rail Section for Testing:

      1) Composition: three feet of contact rail with splice joint centered and between test probes in section.

      2) Quantity: 20 joints per mile.

      3) Selection of locations used for testing will be made by the Engineer.

   c. Reference of Comparison: three feet length of solid contact rail.

   d. Instrumentation:

      1) Digital low resistance ohmmeter (DLRO).

      2) Calibration: Certified by testing laboratory at intervals of not more than six months.

      3) 500 ampere power supply.

   e. Test Procedures:

      1) Mount probes in a holding vise or jig accurately within 3/8 inch of required spacing.

      2) Position vise or jig correctly to ensure that splice will be centered within 1/8 inch.

      3) Check electrical wiring to ensure proper connections and obtain correct resistance reading.

      4) Read microhm across the test section of contact rail and across the three-foot length of solid contact rail section, using a minimum of 500 amperes of test current.

      5) Resistance through splice of test section shall not be more than the resistance of the solid contact rail section.

6) Replace splice joints exhibiting resistance more than that of the solid contact rail section. Retest until resistance reading through the splice does not exceed allowable resistance.

7) If one of the splice joints tested is defective, test resistivity of every completed contact rail splice joint.

3. Alignment Test:

   a. Check for conformance to allowable tolerances. Contractor shall design and fabricate a jig approved by the Engineer for contact rail alignment test.

   b. Contact rail alignment shall be within the tolerances specified herein.

4. Insulation Resistance Test:

   a. Test installed new contact rail system in sections without insulated jumper and shunt cables connected by means of a 5000 volt megohmmeter.

   b. Test reinstalled existing contact rail sections without jumper and shunt cables connected by means of a 1000 volt megohmmeter.

   c. Insulation resistance shall not be less than 80 megohms to ground per 1,000 feet of contact rail.

   d. Record and submit test data for District approval.

3.03 CLEAN-UP

A. Remove wrapping paper and clean installed coverboards after installation.

B. Clean installed insulators of foreign material with manufacturer’s recommended cleaning solvent.

TABLE 34 24 13 -1

EXPANSION JOINT ASSEMBLY INSTALLATION AREA

STATION	DATE	TIME	TEMP ^{O}F	RAIL GAP	REMARKS

Performed By: _____

Contractor Representative & Title

Witnessed By: _____

Engineer or Authorized Representative

END OF SECTION 34 24 13

SECTION 34 42 16

TRAIN CONTROL WIRES AND CABLES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Conductors

B. Control wires

C. Control cables

D. Power cables

E. Signal cables

F. Bond cables

1.02 RELATED SECTIONS

A. Interface and coordinate the work of this Section with Section 20 70 26, Common Materials and Methods for Electrical Systems, Section 26 05 24, Low and Medium Voltage Wires and Cables, Section 20 50 13, Raceways for Facility Services, and Section 20 70 23, Electronic Circuits Wires and Cables.

1.03 MEASUREMENT AND PAYMENT

A. General: Train control wires and cables, as specified herein, will not be measured separately for payment but will be paid for as part of the Contract lump sum price for Automatic Train Control System Work as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. American Railway Engineering and Maintenance-of-Way Association (AREMA):

1. AREMA Signal Manual

B. American Society for Testing and Materials (ASTM):

1. ASTM B8 Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

2. ASTM B33 Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes

3. ASTM B172 Specification for Rope-Lay-Stranded Copper Conductors Having Bunch-Stranded Members, for Electrical Conductors

4. ASTM B189 Specification for Lead-Coated and Lead-Alloy-Coated Soft Copper Wire for Electrical Purposes

C. California Code of Regulations (CCR):

1. CCR Title 24, Part 3, California Electrical Code

D. Insulated Cable Engineers Association, Inc. (ICEA):

1. ICEA T-28-562 Test Method for Measurement of Hot Creep of Polymeric Insulations

E. National Electrical Manufacturers Association (NEMA):

1. NEMA HP 100.2 High Temperature Instrumentation and Control Cables Insulated and Jacketed with ETFE Fluoropolymers

2. NEMA WC5 Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy

3. NEMA WC7 Cross-Linked-Thermosetting-Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy

4. NEMA WC8 Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Submittal Requirements: Before installation of wires and cables, submit the following information for each type and size of wire and cable.

1. Manufacturer of wire and cable, and certificate of compliance;

2. Number and size of strands composing each conductor;

3. Conductor insulation composition type in accordance with California Electrical Code, and thickness in mils;

4. Average overall diameter of finished wire and cable;

5. Minimum insulation resistance in megohms per 1000 feet at 30 degrees C ambient;

6. Jacket composition and thickness in mils;

7. Total number of conductors per cable;

8. Shield material, if any, and thickness;

9. Conductor resistance and reactance in ohms per 1000 ft. at 25 degrees C ambient; and,

10. Conductor ampacity at 30 degrees C ambient.

PART 2 – PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Conductors: Conductors shall be of soft or annealed copper and shall be coated with tin, lead, or lead-alloy in accordance with ASTM B33, or ASTM B189 unless otherwise indicated. Stranding of conductors shall conform to the following table unless otherwise indicated:

Exterior power cables, audio frequency track circuit cables, ac track circuit cables, speed command loop cables, switch-and-lock movement cables, wayside signal cables, wayside equipment ground cables, and ground drop lead cables.	ASTM B8, Class C
Crossbond cables, impedance bond or track shunt connections, propulsion bond cables, switch bond cables, and ground bus jumper cables.	ASTM B172, Class K

B. Multi-conductor Cables: Assembly of multi-conductor cables shall conform to the AREMA Signal Manual, Part 10.3.13 and NEMA WC8 as applicable.

C. Insulation: Insulation material for wire-wrap hook-up wire shall be Kapton. Insulation material for rack wires, rack-to-rack cables, chassis and signal ground drop lead cables, and interior power cables shall be ETFE conforming to NEMA HP 100.2. Insulation material for exterior power cables, crossbond cables, impedance bond cables, audio frequency track circuit cables, ac track circuit cables, speed command loop cables, switch-and-lock movement cables, switch-and-lock power cables, wayside signal cables, station-to-station cables, ground bus jumper cables, and signal bond cables, shall be either ethylene propylene rubber (EPR), or cross-linked polyethylene (XLPE), or other synthetic elastomer conforming to the requirements of Part 10.3.16 of the AREMA Signal Manual.

1. Kapton Insulation Thickness: Insulation shall be 1 mil kapton tape with 1 mil teflon binder.

2. EPR or XLPE Insulation Thickness: The thickness of insulation shall conform to Part 10.3.16 of the AREMA Signal Manual.

3. Physical and Electrical Properties of EPR and XLPE insulated cables: The physical and electrical properties of EPR shall conform to Part 10.3.19 of the

AREMA Signal Manual. The physical and electrical properties of XLPE shall conform to Part 10.3.22 of the AREMA Signal Manual.

D. Jacket: Jacket material for single or multi-conductor cables insulated with ETFE shall conform to these Specifications. Jacket material for cables insulated with EPR or XLPE shall be thermoset and low smoke, flame retardant, zero halogen material, meeting the specifications contained herein.

1. Jacket Thickness (ETFE): The average thickness of the jacket on multi-conductor cables jacketed with ETFE shall be not less than the values given in the following table. The minimum thickness shall not be less than 80 percent of the values given in the table.

Diameter of Cable Core (inches)	Jacket Thickness (inches)
Zero to 0.250	0.015
0.251 to 0.425	0.025
0.426 to 0.700	0.030
0.701 and larger	0.050

2. Jacket Thickness: The average thickness of the jacket (other than ETFE) on cables shall not be less than the values given in the following tables. The minimum thickness at any point shall not be less than 80 percent of the values given in the tables.

a. Common overall jacket of multi-conductor cables:

Diameter of Cable Core (inches)	Jacket Thickness (inches)
Zero to 0.425	0.045
0.426 to 0.700	0.060
0.701 to 1.500	0.080
1.501 to 2.500	0.110
2.500 and larger	0.140

b. Outer jacket of single conductor cables:

Conductor Size AWG/kcmil	Jacket Thickness (inches)
No. 16 to No. 2	0.050
No. 1 to 500 kcmil	0.065
500 kcmil to 1000 kcmil	0.080

3. Physical Properties (Other than ETFE): Jacket shall meet the following requirements:

Tensile strength, psi, minimum	1,500
Elongational at rupture, percent, minimum	150
After oven aging for 168 hours at 121 degrees C:	
Tensile strength, minimum percent of unaged value	85
Elongation at rupture, minimum percent of unaged value	60

Oil immersion, for 18 hours at 121 degrees C, ASTM No. 2 oil:	
Tensile strength, minimum percent of unaged value	60
Elongation at rupture, minimum percent of unaged value	60
Moisture absorption, gravimetric method mg/in., maximum,	
168 hours at 70 +/- 1 degrees C	35
Cold bend, 24 hours at minus 25 degrees C	No cracks

E. Hot Creep Elongation Test: Jacket material shall conform to ICEA T-28-562, modified as follows:

Temperature	200 degrees C
Maximum elongation at 29 psi stress, weight	25 percent
Maximum set	10 percent

F. Color Coding of Conductors. Color coding of conductors shall be in accordance with Section 26 05 24, Low and Medium Voltage Wires and Cables, and the following:

1. Multi-conductor Switch-and-Lock Movement Control and Indication Cables: Color sequence shall be in accordance with NEMA WC5, Appendix K, Method 3 or 4.

2. Two-Conductor Switch-and-Lock Movement: Color shall be black.

2.02 SPECIFIC REQUIREMENTS

A. Intra-Cabinet Wires. Intra-cabinet wires used for signal circuits shall be stranded-conductor wire No. 16 AWG, minimum, and shall be rated at 600 volts. This wire shall be provided for crimped or soldered connections within the cabinets only.

B. Inter-Cabinet Cables. Inter-cabinet cables shall be stranded, single or multi-conductor cable, No. 16 AWG, minimum, for single-conductor cable and size No. 20 AWG, minimum, for multi-conductor cable and shall be rated at 600 volts for both signal and power circuits.

C. Interior Power Cables. Interior power cables shall be stranded, single or multi-conductor cable, No.12 AWG minimum, and shall be rated at 600 volts. This cable shall be provided only for power circuits installed indoors.

D. Exterior Power Cables. Exterior power cables shall be stranded, single or multi-conductor cable, No.12 AWG, minimum, and shall be rated at 1,000 volts. This cable shall be provided only for power circuits installed outdoors.

E. Crossbond Cables. Crossbond cables shall be stranded class H, single-conductor cable, size 500 kcmil and shall be rated at 2000 volts DC.

F. Impedance Bond Cables. Impedance bond cables shall be stranded class H, single-conductor cable, size 500 kcmil, and shall be rated at 2000 volts DC. This cable

shall be provided for connection between the impedance bond and the rail or between impedance bonds.

G. Audio Frequency Track Circuit Cables. Audio frequency track circuit cables shall be stranded, twisted pair, No. 16 AWG minimum, and shall be rated at 1000 Volts. Cable may be shielded as required by the circuit design.

H. AC Track Circuit Cables. AC track circuit cables shall be stranded, single or multi-conductor cable, No. 6 AWG minimum, and shall be rated at 1000 volts.

I. Speed Command Loop Cables. Speed command loop cables shall be stranded, single conductor cable, No. 10 AWG minimum, and shall be rated at 1000 volts.

J. Switch-and-Lock Movement Control Cables. Switch-and-lock movement control and indication circuit cables shall be stranded, multi-conductor cable, No. 14 AWG minimum, and shall be rated at 1000 volts.

K. Switch-and-Lock Movement Power Cables. Switch-and-lock movement power cables shall be stranded, three-conductor cable, No. 6 AWG minimum, rated at 1000 volts.

L. Wayside Signal Cables. Wayside signal cables shall be stranded, single- or multi-conductor cable, No. 14 AWG minimum, and shall be rated at 1000 volts.

M. Signal Bond Cables. Signal bond cables shall be stranded, single conductor cable, No. 6 AWG minimum, and shall be rated at 1000 volts.

N. Rail Head Bonds. Rail head bonds shall be C type, cadmium bronze, conforming to the AREMA Signal Manual, Part 8.1.30. Each wire making up the bond shall have a nominal diameter of 0.0125 inches. The finished cable shall have a nominal diameter equivalent to 250 kcmil.

O. Chassis and Signal Ground Drop Lead Cables. Chassis and signal ground drop lead cables shall be stranded, single-conductor cable, size No. 6 AWG, and shall be rated at 1,000 volts.

P. Wayside Equipment Ground Cables. Wayside equipment ground cables shall be stranded, single-conductor cable, size No. 6 AWG minimum, and shall be rated at 1,000 volts.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Coordinate installation of train control wires and cables with the requirements of Section 20 70 26, Common Materials and Methods for Electrical Systems, Section 20 50 13, Raceways for Facility Services, Section 26 05 24, Low and Medium Voltage Wires and Cables, Section 20 70 13, Common Materials and Methods for Electronic Services, and Section 20 70 23, Electronic Circuits Wires and Cables.

3.02 IDENTIFICATION

A. Identification of wires and cables shall be in accordance with Section 26 05 24, Low and Medium Voltage Wires and Cables, and Section 20 70 23, Electronic Circuits Wires and Cables.

3.03 TESTING

A. General: Testing shall be in accordance with Section 01 45 24, Testing Program Requirements.

B. Testing: Physical and electrical properties of ETFE shall be tested in accordance with NEMA HP 100.2. Physical and electrical properties of EPR shall be tested in accordance with NEMA WC8 and Part 10.3.19 of the AREMA Signal Manual. Physical and electrical properties of XLPE shall be tested in accordance with NEMA WC7 and Part 10.3.22 of the AREMA Signal Manual.

END OF SECTION 34 42 16

SECTION 34 42 19

MICROPROCESSOR-BASED INTERLOCKING HARDWARE

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Vital Microprocessor Based Interlocking Controller

1.02 RELATED SECTIONS

A. Interface and coordinate the work of this Section with Section 20 70 23, Electronic Circuits Wires and Cables, Section 34 42 24, Train Control Room Equipment

1.03 MEASUREMENT AND PAYMENT

A. General: Microprocessor-based interlocking hardware, as specified herein, will not be measured separately for payment but will be paid for as part of the Contract lump sum price for Automatic Train Control System Work as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM A167 Stainless Steel
2. ASTM B36 Cartridge Brass
3. ASTM B140 Commercial Bronze

B. Federal Standards (FS):

1. FS QQ-S-766 Steel, Corrosion Resistant
2. FS QQ-N-290 Nickel Plating, Electrodeposited

C. Institute for Printed Circuits (IPC):

1. IPC-CM-770E Guidelines for Printed Board Component Mounting

D. Military Standards:

1. MIL-G-45204 Gold Plating; Electrodeposited
2. MIL-C-50 Copper Alloy Number 260 (Cartridge Brass)
3. MIL-STD-10 Surface Roughness, Waviness, and Lay
4. MIL-STD-105 Sampling Procedures and Tables for Inspection by Attributes

5. MIL-STD-202 Test Methods for Electronic & Electrical Component Parts

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Submit the following drawings, data, and procedures for approval prior to furnishing and installing the equipment:

1. Complete system data flow and software architecture diagrams for all VMIS modules of the system and all interfaces to the system.

2. Complete circuit drawings and systems diagrams, in a manner as hereinafter specified, for all system and subsystem interfaces, including interconnections of all hardware to the system.

3. Complete power distribution circuit drawings and schematics, as hereinafter specified.

4. Complete rack layout and arrangement plans.

5. Complete equipment plans and installation drawings showing all components of the system. These drawings shall include complete keyed parts lists for all components of the system, racks, terminal boards, plug connectors, cable boots, mounting hardware, and all other rack mounted equipment and hardware.

6. Software listings and logic diagrams for application dependent software.

7. Drawings showing details of interconnecting cables, plug couplers, terminal boards, and other interconnecting devices complete with keyed parts lists and cable assembly instructions.

8. Complete predicted Reliability and Maintainability (R&M) calculations. Actual performance data for a like system for which reliability records have been maintained for a period of not less than three (3) years, may be used to support or substantiate the submitted predicted R&M calculations

9. Complete power calculations for all power sources energizing the vital controllers or controlled, or switched, by vital controllers. Where manufacturer's specific ripple or regulation specifications exist for the vital controllers or associated equipment relying upon these power sources, compliance with such ripple or regulation specifications shall be demonstrated to the satisfaction of the Engineer.

10. Factory Test Procedures designed to demonstrate that the manufactured system will be tested to verify that it performs all functions in accordance with these specifications and in accordance with the approved plans.

11. Subsequent to Factory Testing, certified factory test reports.

12. Complete and comprehensive Installation and Inspection Procedures.

13. Field Test Procedures in accordance with the testing section of these Specifications to verify that the installed system meets all safety and operational requirements of these Specifications and that it has been installed in accordance with the final approved plans.

14. Field Test Reports complete with data results.

C. The Contractor shall provide ten (10) complete sets of application, service, and development system manuals, including manuals covering all software and hardware provided as part of the application software development system required as part of this Contract.

1.06 QUALITY ASSURANCE

A. The system shall be designed to operate in accordance with all applicable AREMA recommendations for the control and indication of interlocking safety functions.

B. The design of the system shall comply in every respect with the latest Rules and Regulations Governing Railroad Signal and Train Control Systems as issued by the office of Safety, Federal Railroad Administration, and of any supplements thereto that become effective before this Contract is awarded.

C. The Contractor shall certify that the entire vital microprocessor system type being furnished under this Contract has been tested to successfully operate in the high electric background noise environment of an operating railroad. The system shall comply with the requirements of MIL STD 461 where applicable to a railroad type environment.

D. The Contractor shall certify that the proposed type system has been successfully operated after being exposed to vibration of 2-10 Hz, 0.2-inch displacement, peak-to-peak and 10-500 Hz at 1.0 G as prescribed by MIL STD 810C, method 514.2, category F, and to shock of 3 G as prescribed by MIL STD.810C method 516.2, Sawtooth Procedure I, Transit Drop Procedure I.

E. All components of the system, except LCD terminals and printers shall be capable of continuous operation at temperatures of –40 degrees F to 160 degrees F and humidity levels of 5 percent to 95 percent, noncondensing, without the need of any external environment controls. The LCD terminals and printers shall be capable of continuous operation at temperatures of 0 degrees F to 105 degrees F and humidity levels of 10 percent to 95 percent.

F. No failure of any component of the vital controllers shall cause the vital microprocessor interlocking system to falsely or erroneously maintain for any reason a permissive state.

G. Printed circuit board pin and socket contacts shall be in accordance with the specified Standards.

1.07 SHIPMENT AND HANDLING

A. Equipment furnished under this Section shall not be shipped until the Engineer has approved the factory test reports, in writing.

B. Each item of the VMIS shall be inspected by the Contractor and the Engineer for shipping damage prior to installation.

C. Any equipment showing signs of damage shall be repaired or replaced, at the Engineer's option, without any additional cost to the Contract.

D. Equipment shall be shipped in suitable crating and shall be properly braced to prevent damage during shipment.

PART 2 – PRODUCTS

2.01 GENERAL REQUIREMENTS

A. The Work includes furnishing, testing, and documenting pre-wired vital microprocessor based interlocking controller racks and local control panels that provides the functionality as shown on the Contract Drawings. BART will furnish vital application logic programs in ladder logic or Boolean equation format.

B. The interlocking controller and all components associated therewith must have a demonstrable history of safe and reliable use in revenue operation in a similar operating environment to that of the existing BART commuter rail/rapid transit operation.

C. Protection against surges, spikes and over-voltage shall be provided. The Contractor shall protect all power feeds, input and output leads, and all other auxiliary equipment with lightning and surge protection as necessary.

D. Interconnection with non-vital supervisory control equipment shall be as shown on the Contract Drawings and as specified herein. Interface with other vital field signal control systems shall be as required to provide failsafe control of the signal system.

E. The interlocking controller or Vital Microprocessor Interlocking System (VMIS) as herein specified shall be designed on the basis of closed loop principles, software diversity and use of proven vital hardware design techniques to achieve safety. The use of multiple processor arrangements based upon voting to enhance the probability of achieving safety is not acceptable.

2.02 DESIGN REQUIREMENTS

A. BART presently uses GETS VHLC'S and Alstom VPI's for their Vital Micro processor systems. If the Contractor chooses to use another type system, in accordance with these specifications, the Contractor shall provide a complete spare unit for maintenance purposes. Additionally the Contractor shall provide training in the programming, set up and testing of the alternate system. The training will be for a 4-

week period for BART's Engineering and Maintenance personnel. BART will provide the application dependent software for a VHLC or VPI system. If the Contractor uses a different system then it shall be the Contractors responsibility to convert the application software to work with the approved system. The VMIS design shall be based upon solid state microprocessor technology and shall not require any off-line storage devices for operation or start up. The operation of the system shall be programmed in solid-state memory. In addition, other functions as specified herein shall be part of this system.

B. Instrument Rack Arrangement Plans shall be as shown in the Contract Drawings. The placement of all rack-mounted components shall be clearly shown. Front, side, and rear views shall be shown on each rack arrangement plan. Only one instrument rack shall appear on each sheet. All rack grounding and component grounding details shall be shown.

C. All plug-connected cables associated with the instrument rack shall be identified by reference numbers and shall be shown connected to the proper plug receptacle.

D. Cable Assembly Drawings shall be furnished for all cables employed by the interlocking system. All plug or receptacle pin assignments shall be shown. All wire gauge, wire color-coding, and wire lengths shall be shown. Shield grounding arrangements shall be shown. A list of tools required and instructions for fabrication of the cables shall be provided on the drawings. All parts or materials necessary for reordering shall be shown and identified with a reference number. This reference number shall correspond with a tabulation of material showing part numbers and quantities included on the cable assembly drawings.

E. Complete Cable Schematic Drawings shall be furnished for all data communications cables employed by the system. All plug or receptacle assignments shall be shown. All wire color-coding, functional wire nomenclature, and plug, slot, and rack or card file destinations shall be shown.

F. Complete Circuit Drawings shall be designed and furnished. All hardwire input and output circuit drawings shall be shown complete with all terminal designations, terminal board locations, printed circuit board edge connector or plug connector designations, and functional wire nomenclature. Card file or rack number and slot locations of all printed circuit boards shall be shown.

G. Signal Lighting Circuit Drawings shall include all wires and termination points from the printed circuit cards to the signal lamps on one sheet.

H. Switch Operating Circuit Drawings shall include all wires and terminations from the printed circuit boards to the switch control relays on one sheet.

I. Switch Indication Circuit Drawings shall show all wires and terminations from the printed circuit boards to the entrance racks.

J. Track Repeater Circuit Drawings shall show all wires and terminations from the printed circuit boards to the track relays.

K. Wire sizes shall be clearly identified on each circuit drawing.

L. Power distribution schematics shall be furnished showing all rectifiers, power supplies, terminals, cables, busses, wires, and wire sizes for all power sources energizing the vital controllers or controlled or switched by the vital controllers. LED equipped rail mounted terminal blocks shall be utilized for all power to the VMIS, the VMIS I/O, and the VMIS serial controllers.

M. The VMIS application software documentation shall be provided, showing progression of switch control from the supervisory system inputs to the switch control relays, examples of route, time, and switch locking, progression of signal control from the supervisory system inputs to the signal lamps, and examples of all other logic executed by the vital interlocking system.

N. All data passed from one vital controller to another vital controller and all data passed from any vital controller to the supervisory system shall be identified as well as all hardwire interfaces. All terms in the logic expressions and all data received by or sent from the controllers shall be identified with standard BART relay logic nomenclature. Translation tables will not be acceptable.

O. The operating instructions for the VMIS shall be divided into application and executive dependent portions. The executive instructions shall be stored in solid state read only memory (ROM) or solid-state Programmable Read Only Memory (PROM) devices and shall be referred to as the Executive Firmware. The application dependent instructions shall be stored in solid-state Erasable Programmable Read Only Memory (EPROM) devices and shall be referred to as the Application Dependent Firmware. The executive firmware and application firmware shall reside in separate memory devices.

P. A complete Application Dependent Firmware Development System shall be furnished as specified herein.

Q. The Vital Processor Units shall be equipped with on-board diagnostics. These diagnostics shall quickly and reliably identify failed printed circuit boards. The nature of the failure as well as the specific location of the failure shall be indicated. All on board diagnostics shall be accessible to a dial-in telecom line for access by a/the remote diagnostics terminal.

2.03 VITAL CONTROLLER EXECUTIVE FIRMWARE

A. The executive firmware shall continuously test for a loss of control over the state of the hardwire outputs, a loss of control over RAM, a loss of vital data communications, and a spontaneous change in the application dependent firmware.

B. The executive firmware shall log all vital and non-vital failures and identify the faulty printed circuit card or function.

C. The executive firmware shall supervise a closed loop monitoring system for all hardwire input and output functions.

D. All functions required for system integrity evaluation, error logging, hardwire interface, timing, data communications, application logic execution, and the application of power to the vital controller shall be fully interleaved and executed by

the vital processor. Failure to pass any of the system integrity tests shall cause the system to cease all data communications and remove power, in a completely fail safe manner, from the hardwire outputs.

2.04 APPLICATION DEPENDENT FIRMWARE

A. The application dependent firmware shall define the operation of the VMIS; the operation of the individual functions shall be as indicated on the Contract Drawings and shall include, but not be limited to:

1. Route Check
2. Signal Control
3. Signal Lighting
4. Signal Indication
5. Time Locking
6. Route Locking
7. Switch Locking
8. Switch Control
9. Switch Indication
10. Switch Correspondence
11. Loss of Shunt
12. Non-vital processing for the following controls:
    a. Route setting including:
        1) Switch Operation
        2) Signal Operation
    b. Route Cancellation
    c. Auxiliary Functions
13. Non-vital processing for the following indications:
    a. Signal Operation
    b. Switch Position
    c. Switch Locking
    d. Track Occupancy
    e. Alarm and Auxiliary Status

f. System Failure Indication

14. All necessary data communication conditioning including the building of repeaters.

B. The application dependent firmware shall be keyed to the vital controller hardware rendering it impossible for any application dependent firmware to be executed in any vital controller other than the intended vital controller.

C. The application dependent firmware shall be stored on an EPROM device and shall be replaceable without disturbing the executive firmware.

2.05 GENERAL HARDWARE AND OPERATING REQUIREMENTS

A. The VMIS shall consist of a number of Vital Processor Units and the associated cables, plugs, wire connectors, terminal blocks, power conditioning equipment and hardware.

B. Each Vital Processor Unit shall consist of printed circuit boards of the various types, as specified herein, mounted within card files in one instrument rack. VMIS units when mounted shall have access from the rear.

C. All plug connectors, data transmission equipment, power supplies, power conditioning devices, terminal boards, wire connectors, and other equipment required to achieve a complete, stand-alone subsystem shall be mounted within the instrument rack along with the associated vital processor units.

D. The vital processor units shall be provided with Double Break Vital Output Printed Circuit Boards (DBVO) and Vital Input printed Circuit Boards (VI) as specified herein. A sufficient number of these types of printed circuit boards shall be installed in each vital processor unit to accommodate all vital hardwire inputs and outputs.

E. The vital processor units shall be provided with Non-vital Input/Output Printed Circuit Boards (NVI/NVO) as specified herein. A sufficient number of these type printed circuit boards shall be installed in the vital processors to accommodate all non-vital hardwire inputs and outputs.

F. The hardware interface I/O board shall indicate, with logically grouped lights mounted on the interface boards, the status (Hi or Lo) of each input or output. An approved lamp labeling system shall be provided as part of the unit, visible when viewing the status lamps.

G. The Vital Processor Units shall be provided with Vital Lamp Driver Printed Circuit Boards as specified herein. A sufficient number of these types of printed circuit boards shall be installed in each Vital Processor Unit to accommodate all vital signal lamp outputs within that Vital Processor Unit’s scope of control.

H. The use of external relays as interface devices between the Vital Processor Units and external circuits shall be as specified herein, or as indicated on the Contract Drawings. If the vital microprocessor interlocking units furnished by the Contractor require more external relays as interface devices than is shown on the contract

drawings or specified herein, then it shall be the Contractor's responsibility to furnish such relays as part of the contract to provide a complete VMIS.

I. The Vital Processor Units shall have a twenty percent (20%) expansion for storage of application dependent firmware and capability, through space, for additional printed circuit boards.

J. Each Vital Processor Unit shall be provided with Vital Serial Communication Ports as specified herein. The number of Vital Serial Communication Ports shall be sufficient to allow interconnection of the Vital Processor Units in accordance with the Contract Drawings and as required. Communication of data between the Vital Processor Units shall be transmitted through these Vital Serial Ports.

K. Each Vital Processor Unit shall also be provided with Non-Vital Serial Communication Ports as specified herein. The number of Non-Vital Serial Communication Ports shall be sufficient to allow interconnection of the Vital Processor Units and the supervisory control system for data communication as indicated on the Contract Drawings. Non-vital serial communications ports shall be configured for communications via the fiber optic modems as specified herein.

L. Each Vital Processor Unit card file(s) or pair of card files shall contain printed circuit boards of the types described herein. Additional types of printed circuit boards required for the operation of the Vital Processor Units shall be furnished and installed as required. Combination of functions among the board types shall be allowed only as specified herein.

M. The printed circuit boards shall be housed within a card file and be of the plug-in type. Keys shall be provided on the card file to prevent the insertion of improper printed circuit board types.

N. The card files shall be factory mounted in a standard 19 inch instrument racks. The rail mounted terminal blocks shall interface all wire connections to the cardfiles. No forced air ventilation shall be used.

O. The design shall provide that all cables or wiring leaving the rack shall be routed through rubber boots at the top of the racks and be provided with means to be neatly routed and securely fastened with tie straps.

P. All power conditioning including, but not limited to, surge and noise suppression required on the power feeds for the rack mounted power supplies shall be located on the VMIS rack.

Q. The hardwire inputs of the vital controllers shall not respond to ac voltage levels. The hardwire inputs shall be biased and shall not, under any failure condition, respond to any voltage of improper polarity.

R. The hardwire outputs of the vital controllers shall provide security equal to, or greater than, conventional double-break relay circuits for any circuits leaving the housing.

2.06 VITAL PROCESSOR UNIT PRINTED CIRCUIT BOARDS

A. Each Vital Processor Unit shall be equipped with one Central Processing Unit Printed Circuit Board (CPU PCB). CPU PCBs throughout the Vital Processor System shall be identical with the exception of the instructions stored in the Application Dependent Firmware PROM and a keying system that shall prevent operation of the Vital Processor Units when a CPU PCB from another Vital Processor Unit is installed. This Contractor shall demonstrate that the keying system is designed according to accepted fail-safe principles. The CPU PCBs shall conform to the requirements shown below:

1. The CPU PCBs shall contain the microprocessor, clock, random access memory (RAM), Executive Firmware, Application Dependent Firmware, data bus, address bus, and all other components of the computing portion of the system. Other printed circuit boards comprising the system shall be input-output adapters and interfaces only.

2. The CPU PCBs may contain the hardware for the Vital and Non-vital Data Serial Communication Printed Circuit Boards as specified herein.

3. The CPU printed circuit boards shall not perform any of the functions or affect any of the connections to external devices specified for the hardwire interface printed circuit boards.

4. The Application Dependent Firmware PROMS shall be mounted on the CPU printed circuit boards via sockets, the contacts of which shall be fabricated from commercial bronze or brass and plated with gold over nickel underplate.

5. Wire jumpers and piggy back boards shall not be used unless permitted by the Engineer.

B. Each Vital Processor Unit shall be equipped with one Non-Vital Serial Interface Printed Circuit Board (NVSI PCB). NVSI PCBs throughout the Vital Processor System shall be identical. The NVSI PCBs shall conform to the following requirements:

1. The NVSI PCBs shall contain two RS232C compatible serial ports.

2. One port shall be configured as a master with the ability to initiate communications with and discretely address an approved number of other serial ports electrically connected to a common serial line. The maximum number of such slave ports shall be the manufacturer’s standard.

3. The slave port shall be configured with the ability to select one of an assigned number of address codes. The slave port shall receive and transmit data only when the master port connected to the common serial line specifies an address that corresponds to the slave port’s address.

4. Data transmission rates for all non-vital serial ports shall be independently adjustable. The method of adjustment, maximum adjustable bits per second (BPS), and optimum adjusted BPS shall be as approved by the Engineer.

5. Communications protocol for all serial data communications lines shall be compatible with all connected devices, as indicated on the Contract Drawings, including fiber optic modems.

6. Data communications cables shall be plug connected to the NVSI PCBs. Cable shielding shall be connected to ground on one end only.

C. Each Vital Processor Unit shall be equipped with Vital Input Printed Circuit Boards (VI PCBs) as specified herein.

1. VI PCBs shall be furnished and installed in sufficient number to accommodate all vital inputs within the VMIS's scope of control including, but not limited to:

   a. One input from each vital track relay front/heel contact.

   b. One input from each switch and lock movement normal position indication circuit.

   c. One input from each switch and lock movement reverse position indication circuit.

   d. One input from each electrical switch lock normal position indication circuit.

   e. One input for each possible polarity of each vital line circuit.

2. The VI PCBs shall accept inputs without the use of external or board mounted interface relays. Energy for the inputs shall flow directly from the relay contacts, line circuits, or signal equipment as described herein, through the specified cables and internal signal instrument house wiring.

D. Each VMIS unit shall be equipped with Vital Output Printed Circuit Boards (VO PCBs) as specified herein.

1. VO PCBs shall be furnished and installed in sufficient number to accommodate all vital outputs within the Vital Processor Unit's scope of control including, but not limited to:

   a. Two outputs to each switch and lock movement controller relays.

   b. One output for each possible polarity of each vital line circuit feed.

2. The VO PCBs shall output energy directly to the relay coils, line circuits, or signal equipment as described herein, through the specified cables and internal signal instrument house wiring.

E. Each Vital Processor unit shall be equipped with solid-state vital timers as specified herein.

1. Vital timers shall be furnished in sufficient number to accommodate all vital timing functions within the Vital Processor Unit's scope of control, including, but not limited to:

   a. Loss of shunt time for track repeater relays.

b. NPS timers for each signal.

2. Vital timers shall be field settable and shall be selectable by a means other than by modification to the application software designed for the interlocking.

3. Vital timer selection switches shall be covered and sealed to provide and insure the integrity of the settings and prevent accidental contact.

F. Each Vital Processor Unit shall be equipped with Vital Lamp Driver Printed Circuit Boards (VLD PCBs) as specified herein.

1. VLD PCBs shall be furnished and installed in sufficient number to accommodate all vital signal lamps within the Vital Processors Unit's scope of control.

2. The VLD PCBs shall output energy directly to the signal lamps as described herein through the specified cables and internal signal instrument house wiring.

3. The allowable wattage for VLD PCB outputs shall be adequate to handle the designed maximum lamp load for the Contract, as approved by the Engineer.

2.07 FACTORY TESTING

A. General: Testing shall be in accordance with Section 01 45 24, Testing Program Requirements.

B. The VMIS and all subsystems shall be tested in accordance with the approved Factory Test Procedure and with the applicable BART testing requirements.

C. The VMIS shall be in compliance with and have means of accessibility to permit all testing as required by the current edition of the "Rules and Regulations Governing Railroad Signal and Train Control Systems" as issued by the Federal Railroad Administration. If the Contractor's system requires any external equipment to permit making such tests then such equipment shall be furnished as part of the system.

PART 3 – EXECUTION

3.01 INSTALLATION

A. The card files shall be mounted in standard 19-inch instrument racks.

B. All cables or wiring leaving the instrument racks shall be routed through rubber boots at the top of the racks and shall be neatly routed and securely fastened with tie straps.

C. The mounting of card files and associated equipment shall provide for easy access to all test points, indicators, and adjustments.

D. Mounting height of microprocessor equipment within a signal instrument house or room shall be restricted to an area between 2.5 feet and 5.5 feet above the finished floor.

3.02 IDENTIFICATION

A. Card files shall be supplied with a printed label that identifies the input and output ports on the PCB by the name assigned to the port in the application firmware.

B. Ports shall be identified by the slot number of the PCB and the port number on the PCB.

C. A method, as approved by the Engineer, shall be used to mount a typed, or printed, name tag on a front plate of each rack or cabinet.

3.03 FIELD TESTING

A. General: Testing shall be in accordance with Section 01 45 24, Testing Program Requirements.

B. The VMIS and all subsystems shall be tested in accordance with the approved Installation Test Procedure and the BART testing requirements.

C. The latest type test unit for testing vital microprocessor interlocking equipment, as recommended by the manufacturer, shall be furnished to the Engineer, to assist diagnosing modules during a failure mode. This unit shall be designated the remote diagnostics terminal. The remote diagnostics terminal shall be configured for local and remote diagnostics. The remote diagnostics terminal hardware shall be as defined for, but separate hardware from, the lap-top PC specified for the ERS AHCW Analyzer interface computer. All controls required for normal diagnostic inquiries shall be in English dialogue.

END OF SECTION 34 42 19

SECTION 34 42 24

TRAIN CONTROL ROOM EQUIPMENT

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Vital relays

B. Non-vital relays

C. Timer equipment

D. DC power supplies

E. Frequency converters

F. Signal transformers

G. Ground detectors

H. Lightning protection

I. Filters

1.02 MEASUREMENT AND PAYMENT

A. General: Train control room equipment, as specified herein, will not be measured separately for payment but will be paid for as part of the Contract lump sum price for Automatic Train Control System Work as indicated in the Bid Schedule of the Bid Form.

1.03 REFERENCES

A. American Railway Engineering and Maintenance-of-Way Association (AREMA)

1. AREMA Signal Manual

1.04 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Submit product information and catalog cuts of equipment and devices specified herein.

C. Submit samples of vital and non-vital relays upon request by the District.

PART 2 – PRODUCTS

2.01 VITAL RELAYS

A. General: Vital relays shall include biased-neutral relays and AC relays. Vital relays shall conform to AREMA specifications. Product information for all vital relays shall be submitted for approval.

1. Shipping: Vital relays shall be shipped separately from the equipment racks in which they are to be mounted.

2. Plug-In Type: Vital relays shall be of the plug-in type. Relays of the same type shall be uniform in design and contact assembly. Relays shall be furnished with transparent dustcovers of nonflammable material. A machine-printed laminated or other permanent type name tag shall be fixed mechanically without glue on each relay cover. The name tag shall be removable and replaceable, but shall not vibrate loose under normal operating conditions.

3. Relay Mounting: Relays shall be mounted in cabinets only after cabinets have been installed. As relays are mounted, record relay serial numbers corresponding to cabinet location. Relays shall be secured against vibrations. Vital relay plugboards shall be front-frame mounted. Vital relay plugboards shall be secured with bolts, lock washers, and nuts.

4. Vital Relay Plugboards: Plugboards for plug-in vital relays shall be provided with removable contacts. Wires shall be attached to these removable contacts. The plugboard shall be designed so that the removable contact shall have a direct connection with the relay coil and the relay contact prongs. The plugboards shall conform to AREMA Signal Manual, Part 6.2.1. The wiring to each removable plugboard contact shall carry a District approved tag indicating the relay contact or coil number assigned to the wire. The back of the plugboards shall be tagged to indicate the nomenclature of the relay for which the plugboard is wired. The contact numbering system shall be uniform for each type of relay used.

5. Keying: The relays and plugboards shall be mechanically keyed to prevent relays of the incorrect style, contact arrangements, or operating characteristics from being inserted on any given plugboard. Keying on relays and plugboards shall be the manufacturer’s standard keying.

6. Surge Suppression: Surge suppression for all vital DC relay coils shall be provided. A transient sensing device, such as a transorb, shall be connected in parallel with each relay coil, and shall be built into the relay or its plugboard, or shall be mounted to the back of the plugboard in a manner that has been approved by the District.

7. Contact Resistance: The contact resistance of vital relays shall meet the requirements of the AREMA Signal Manual, Part 6.2.1, Section L, Subsections 8 and 9.

8. Spare Contacts: Each vital relay provided shall have a minimum of one spare dependent front-back contact, or one spare independent front and one spare

independent back contact, or one spare dependent normal-reverse contact except as indicated below:

a. Where a single repeater relay is used, either the repeater relay or the primary relay shall have a minimum of one spare dependent front-back, or one spare independent front and one spare independent back contact, or one spare dependent normal-reverse contact.

b. Where more than one repeater relay is used, the final repeater relay and the primary relay shall have a minimum of one spare dependent front-back contact, or one spare independent front and one spare independent back contact, or one spare dependent normal-reverse contact. These spare contact requirements shall be met throughout the installation and test period and at the conclusion of any and all field corrections.

9. Nominal Operating Voltage: Vital DC relays shall operate at a nominal voltage in the range of 12 to 28 volts.

B. Biased-Neutral Relays: Vital biased-neutral relays shall meet the requirements of the AREMA Signal Manual, Part 6.2.1 and Part 6.1.5, Section G, subsections 7, 8, and 9.

1. Contacts: Each vital biased-neutral relay shall have a minimum of four independent front contacts, two dependent front-back contacts, and two independent back contacts unless otherwise approved by the District.

2. All front contacts shall be silver-to-metalized carbon contacts. Metal-to-metal contacts, front and back, may be allowed for limited applications only if specifically approved by the District.

C. Switch Operating Relays or Biased Neutral Controller: One normal and one reverse switch operating relay, or equivalent, shall be provided for each switch-and-lock movement. Switch operating relays used to control the polarity of the operating current for switch-and-lock movements shall meet the same requirements as specified herein above except as follows:

1. Contacts. Each switch operating relay shall have a minimum of either two dependent front-back contacts or two independent front contacts and two independent back contacts. Each contact shall be equipped with a magnetic blow-out feature to effectively interrupt high currents and minimize contact wear. Each contact shall be capable of interrupting the normal switch-and-lock movement operating current.

D. Switch Overload Relay: One switch overload relay shall be provided for each switch-and-lock movement. Each switch overload relay shall be equipped with a timer which will cause the relay to energize eight seconds after a switch position change is requested should the switch fail to achieve correspondence with the requested position. Upon expiration of the 8-second timer, the switch overload relay shall de-energize the active contactor. Upon request of the switch to the alternate position, the overload relay shall release allowing operation of the alternate contactor and simultaneously the timer will reset and initiate the timing cycle to verify completion of the alternate switch position request.

E. Vital AC Relays: Vital AC relays shall be two-element, 100 Hz vane-type induction relays. Vital AC relays shall be capable of operating continuously and successfully without resultant damage with a minimum voltage range of 100 volts to 135 volts, inclusive, applied to the local winding and with a minimum voltage range of three volts to eight volts, inclusive, applied to the control winding. The minimum pick-up current shall be 0.28 amps applied to the control winding.

1. Contacts: Each vital AC relay shall have a minimum of two independent front contacts and two independent back contacts, unless otherwise approved by the District. Each front contact shall be of the silver-to-metalized carbon type.

2. AREMA Standards: Vital AC relays shall meet the requirements established by AREMA Signal Manual, Part 6.1.35, with the exception that these relays shall be plug-in type; and, therefore, shall not have a screened breather and shall not be equipped with binding posts. These relays shall also meet the requirements established in Section 7, Design, of AREMA Signal Manual, Part 6.2.1, Section G.

2.02 NON-VITAL RELAYS AND TIMER EQUIPMENT

A. General: Non-vital relays and timer equipment are devices used in train control system circuitry not considered to be vital to passenger or train safety. Non-vital relays and timer equipment required to provide a complete and working ATC system shall be furnished. Non-vital relays shall include, if needed, general purpose interfacing relays and heavy duty interfacing relays. Product information for all non-vital relays and timer equipment shall be submitted for approval.

1. Shipping

   a. Non-vital heavy duty interfacing relays may be mounted and shipped in the equipment racks or cabinets in which they are to be used.

   b. Non-vital general purpose interfacing relays shall be mounted and shipped on the printed circuit cards on which they are to be used.

2. Type: Non-vital logic relays (normal acting and magnetic stick) and non-vital heavy duty interfacing relays shall be of the plug-in type. Relays of the same type shall be uniform in design and contact assembly.

3. Mounting: Non-vital general purpose interfacing relays shall be mounted on plug-in type printed circuit cards and shall be soldered to conductors on the cards. Non-vital relays shall be mechanically secured to the plugboard.

4. Name Tags: A machine printed permanent relay name tag shall be mounted on each relay. The relay name tag shall be easily replaceable but shall not come off due to vibration.

5. Printed Circuit Cards:

   a. Each printed circuit card on which non-vital, general purpose interfacing relays are mounted shall have one LED indicator light mounted along the front edge of the card for each relay in such a manner that the lights can be

readily viewed for troubleshooting. The indicating light shall be operated by a contact on the relay so that it will be illuminated whenever the relay is picked up. Each indicating light shall be identified, both on the printed circuit card and on the transparent front plate of the card cage, with the name of the relay it indicates.

b. Groups of printed circuit cards on which non-vital, general purpose interfacing relays are mounted shall be installed in metal printed circuit card cages that have transparent front plates of nonflammable material. The design of the card cage shall permit viewing each relay indicator light without disassembly or other mechanical manipulation.

B. Non-vital, General Purpose Interfacing Relays: Non-vital, general purpose interfacing relays shall be reed relays or crystal case relays, either type with hermetically-sealed contacts and epoxy-encapsulated coils. These relays shall be mounted on printed circuit cards as indicated herein. Non-vital general purpose interfacing relays shall be DC relays with a nominal operating voltage of from 18 volts to 28 volts. These relays shall pick up with 12 volts or more applied to their operating circuit and shall drop out when this voltage is removed. These relays shall be capable of operating continuously with up to six volts above nominal operating voltage applied to their operating circuit. Non-vital, general purpose interfacing relays shall pick up in less than 50 ms when energized with 12 volts or more and shall drop out in less than 50 ms when de-energized from nominal voltage. These times shall be measured from a front contact closure or opening from the instant the switch applying the voltage closes and from the instant the switch removing the voltage opens.

1. Standardization: All non-vital general purpose interfacing relays shall be identical. All printed circuit card assemblies containing non-vital general purpose interfacing relays shall be identical.

2. Contacts: Each non-vital, general purpose interfacing relay shall be equipped with a minimum of two front contacts, one of which shall be used for an indication light circuit. Each contact shall be metal-to-metal and shall be capable of carrying and breaking a load with the following characteristics:

3. Contact Resistance: Each contact shall be capable of breaking a resistive load with these characteristics, or an inductive load suppressed so that at no time during steady state or switching conditions shall the load exceed these characteristics. This operation shall be performed at least 1.5 million times without the contact resistance, measured at 10 ma in a three-volt DC circuit, exceeding three ohms.

   a. Non-vital general purpose interfacing relays shall be capable of the electrical operation indicated herein above after 10 million mechanical cycles without an electrical load on their contacts.

   b. Under all conditions, the minimum open contact resistance shall be 50 megohms at 400 volts DC, and the maximum duration of contact bounce shall be five ms.

4. Surge Suppression: Surge suppression for non-vital general purpose interfacing relay coils shall be built into the printed circuit card on which the relays are mounted. This suppression shall prevent the load presented to a contact controlling each relay coil from exceeding the following values during steady state or switching conditions:

    a. Maximum volt-amp load: 15 VA.

    b. Maximum load current: 1 amp.

    c. Maximum switched voltage: 250 volts.

C. Non-vital Heavy Duty Interfacing Relays: Non-vital heavy duty interfacing relays shall be plug-in DC neutral relays with a nominal operating voltage of from 18 volts to 28 volts. These relays shall pick up with 12 volts or more applied to their operating circuit, and shall drop out when this voltage decreases below 12 volts. These relays shall be capable of operating continuously with up to at least six volts above nominal operating voltage applied to their operating circuit. Non-vital, heavy duty interfacing relays shall pick up in less than 35 ms when energized with nominal voltage, and shall drop out when de-energized from nominal voltage in less than 60 ms. These times shall be measured as a front contact closure or opening from the instant the switch applying the voltage closes and from the instant the switch removing the voltage opens.

1. Contacts: Each non-vital heavy duty interfacing relay shall be equipped with a minimum of two front-back contacts. Each contact shall be metal-to-metal and shall be capable of carrying and breaking a resistive or an inductive load, which does not exceed the following characteristics, one million times. The contact resistance, measured at five amps, shall not exceed one ohm for this operation:

    a. Maximum continuous volt-amp load: 200 VA;

    b. Maximum volt-amp load while relay contact is opening (transient due to inductive surge): 300 VA;

    c. Maximum instantaneous load current: 5 amps;

    d. Maximum continuous load current: 5 amps;

    e. Maximum instantaneous switched voltage: 100 volts DC.

2. Each contact shall also be capable of carrying and breaking a resistive load or an inductive load, which does not exceed the following characteristics, five million times. The contact resistance, measured at 0.5 amp, shall not exceed one ohm for this operation:

    a. Maximum continuous volt-amp load: 50 VA;

    b. Maximum volt-amp load while relay contact is opening (transient due to inductive surge): 90 VA;

    c. Maximum instantaneous load current: 1.25 amps;

    d. Maximum continuous load current: 1.25 amps;

e. Maximum instantaneous switched voltage: 100 volts.

3. Surge Suppression: Surge suppression shall be provided for non-vital, heavy-duty interfacing relay coils.

2.03 DC POWER SUPPLIES:

A. General: Direct current power supplies shall meet the following requirements. Product information for all DC Power Supplies shall be submitted to the District for approval.

1. Operate satisfactorily in both single and parallel (continuous current sharing) modes;

2. Input voltage rating shall be for connection to a 120 volts ac, single-phase, 60 Hz ungrounded power system;

3. Outputs shall be isolated from ground;

4. Additional requirements:

a. Semiconductors shall be silicon type with JEDEC numbers;

b. Transformers shall not emit audible noise in excess of 75 db, referenced to 0.0002 dynes/cm^2 at a distance of two feet, at rated voltage and current;

c. For each type supply, the equipment and ratings shall be identical throughout the system, and the equipment shall be interchangeable;

d. Output voltage shall be nominal plus/minus 5 percent with input variations from 105 to 130 VAC at a temperature of 40 degrees C;

e. Output voltage from zero to full load shall not vary more than three percent within a temperature range of 0 to 50 degrees C;

f. Provide current limiting and adjustable overvoltage protection. Current limiting shall limit output current to no more than 130 percent of the 40 degrees C rated current rating;

g. Provide an adjustable undervoltage detection circuit which shall de-energize a relay with form-C contacts when the output voltage of the power supply falls to a set value. The undervoltage circuits shall reset automatically when the undervoltage condition is removed. The relay outputs shall alarm as indicated;

h. Power supplies shall utilize a diode auctioneering form of loadsharing. Both normal and reserve power supplies shall be on-line at all times with the normal power supply providing 50 percent of the load demands and the reserve power supply providing the remaining 50 percent;

i. Both the normal and the reserve power supply shall be designed and rated for continuous operation at a minimum of 125 percent of the full (normal plus reserve) load; and,

j. Power supply output ripple shall not exceed one percent.

5. Power supplies shall be protected as indicated; and,

6. Power supplies shall be clearly and permanently labeled with the manufacturer's name, serial number, part or model number, and input and output rating.

2.04 FREQUENCY CONVERTERS

A. General: Solid state frequency converters shall meet the following requirements:

1. The frequency converter shall operate from a 120VAC, 60-Hz service and shall have an output of 120VAC at 100 Hz.

2. The converter shall be kept in phase with a phase lock circuit.

3. Frequency converters shall be used in pairs. One converter shall normally supply signal power unless it fails, at which time the redundant converter shall automatically go on-line. Contacts shall be provided to interface to alarm circuitry to indicate when a unit fails, or when a problem occurs affecting the phase lock loop reference signal. Detectable failures shall include:

   a. Overvoltage/undervoltage on output;

   b. Phase relation to sync greater than 10 degrees;

   c. Loss of synchronization signal.

4. Each frequency converter shall be sized to continuously furnish a minimum of 150 percent of the calculated maximum power load for its related location or zone. If the calculated load underestimates the worst case actual load measured during testing and operations, the undersized converters shall be replaced with properly sized converters at no additional cost to the District.

5. Frequency converter equipment shall be of the solid-state, AC power source, synthesized sine wave type.

6. Converters shall meet these minimum requirements:

   a. Load power factor: 0.8 lead or 0.7 lag at rated output;

   b. Efficiency: 70 percent minimum;

   c. Voltage regulation: Plus or minus 1 percent with line fluctuations of plus or minus 10 percent from no load to full load;

   d. Frequency stability: 2 percent minimum;

   e. Harmonic distortion: 4 percent maximum at any load/input specified herein;

   f. Meters: Panel voltmeter, ammeter, and frequency meter with 2 percent minimum accuracy;

g. Output power: Single-phase, two-wire, isolated output adjustable from 105 to 130 volts AC at operating frequency;

h. Protection: Provide input and output circuit protection as indicated.

7. Where more than one converter pair is provided at a given location, one converter pair shall be designated as the master, and all other converter pairs shall be synchronized to the master.

8. Converters shall be designed to allow replacement by one maintenance technician.

9. The design of the frequency converter systems shall be submitted for approval.

2.05 SIGNAL TRANSFORMERS

A. General: The Contractor shall compute the sizes of signal transformers required to feed the loads for the equipment. The transformers shall be air cooled, dry type, and shall be in accordance with AREMA Signal Manual Part 14.2.10 for single phase transformers. Product information for signal transformers shall be submitted to the District for approval.

1. Taps: Primary and secondary taps of all power transformers, except track transformers, shall be brought to a terminal board mounted inside the transformer case. Power transformer secondary windings shall have a minimum of two taps above and two taps below the computed voltage and shall have a 10 percent tap/change ratio. Primary windings shall be equipped with taps to accommodate a 20 percent variance from the supply voltage. A lead for each secondary winding connection and two leads for the primary winding shall be brought out of the transformer case through wall bushings. Primary winding taps shall be provided on terminal boards with bolted jumpers or straps for tap changing.

2. Isolation: Means shall be provided to isolate each transformer for maintenance without interruption in the primary ATC power supply.

2.06 GROUND DETECTORS

A. General: Ground detectors for ac and dc buses shall be located on or in the vicinity of the power racks. Product information on ground detectors shall be submitted to the District for approval.

1. Ground detectors shall have the sensitivity to detect a minimum ground leakage resistance from either ac or dc supply bus. The ground detectors shall be rack mounted in the train control rooms and train control houses. The level of ground detection shall be as approved by the District.

2. Each DC ground detector unit shall be provided with three indications and a test control. Two indicators, one each for positive and negative, shall indicate the presence of a ground. The third indicator shall indicate that the ground detector

is operating properly and no grounds are present. Separate DC ground detectors shall be provided for each DC voltage supply.

3. One AC ground detector shall be provided for each ungrounded AC power supply in each train control room and train control house. Each AC ground detector shall have two indications and a test control. One indicator shall indicate the presence of a ground. The other shall indicate that the ground detector is operating and no grounds are present.

4. Ground detectors at a TCR shall be provided with alarm contacts for connection to a summary alarm to the SCADA system.

2.07 LIGHTNING PROTECTION

A. Provide lightning arresters and other circuit protection devices necessary to protect wayside equipment from damage and false operation due to lightning. The lightning arresters shall comply with AREMA Signal Manual, Part 11.1.10, for lightning protection. Product information for all types of lightning protection shall be submitted to the District for approval.

B. Track circuits entering or leaving the train control equipment room/house shall be protected by gas-type lightning arresters, or District-approved equivalent, located in the train control equipment room/house.

2.08 FILTERS

A. General: Filters for train detection and TWC reception circuits shall be designed for narrow passband and sharp cut-off characteristics. Filters used in fail-safe circuits shall be designed to prevent undesired signals from passing through the filter at levels that could cause unsafe conditions, even in the event of a component failure within the filter.

1. Half power points (3db) shall be a maximum $\pm$ 13 Hz from the center frequency.

2. Ripple within the passband shall not exceed 1db.

3. Filter output shall be down 60db at maximum $\pm$ 75 Hz from the center frequency.

PART 3 – EXECUTION

Not used

END OF SECTION 34 42 24

SECTION 34 42 25

TRAIN CONTROL WAYSIDE EQUIPMENT

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Switch and lock movements

B. Derails

C. Wayside signals

D. Rail connections

E. Conduits, cable trenches and accessories

F. Switch power supply cabinets

G. Track shunts and impedance bonds

H. Insulated joints

1.02 MEASUREMENT AND PAYMENT

A. General: Train control wayside equipment, as specified herein, will not be measured separately for payment but will be paid for as part of the Contract lump sum price for Automatic Train Control System Work as indicated in the Bid Schedule of the Bid Form.

1.03 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Submit product information and catalog cuts of equipment and devices specified herein.

PART 2 – PRODUCTS

2.01 GENERAL: This Section includes specifications for wayside equipment, classified according to the type of ATC system installation.

A. General Application: Wayside equipment applicable to both fixed-block and communication-based train control systems.

B. Fixed-Block: Wayside equipment applicable only to fixed-block ATC systems.

2.02 GENERAL APPLICATION

A. Switch and Lock Movements: Switch layouts shall include switch-and-lock movements complete with hand crank, throw rod, lock rods, point detector rods, front rod, junction box, gauge plate extensions, and all mounting hardware. Product information for the switch-and-lock movement shall be submitted for approval. Switch-and-lock movement shall be specified in the DMP (Designated Matching Product).

1. Uniformity: All switch-and-lock movements shall be of the same type or model.

2. Location: Switch-and-lock movements shall be mounted to the side of the device being controlled as indicated on the Contract Drawings. Access and arrangement of switch-and-lock movements shall permit all working adjustments to be made when the movement is installed and connected.

3. Integral Unit: Switch-and-lock movements shall be complete with integral units including motor, driving mechanism, throw mechanism, lock devices, dual point detectors, overload protection, circuit controller, and terminal board.

4. AREMA Standards: Switch-and-lock movements shall conform to all requirements specified in the AREMA Signal Manual, Part 12.2.1, Sections D through K.

5. Power: Power for switch-and-lock movements shall be supplied from wayside switch power supply cabinets (SPSC) as indicated. All necessary cables, conduits, transformers, switches, and accessories required for distributing power for switch-and-lock motors shall be furnished.

    a. Switch-and-Lock Movement Operating Power: Switch-and-lock movements shall operate from 110 V ac power.

    b. Overload Protection: Switch-and-lock movements shall be provided with overload protection to disconnect power from the motor should the movement fail to complete within eight seconds. The overload protection shall be reset by a switch call opposite to the original switch call.

    c. Loading Current: Power shall be provided to simultaneously operate the maximum number of switch-and-lock movements required for available routes at an interlocking as indicated by the route and aspect charts, assuming each motor is drawing its overload current.

    d. Switch Motor: The switch machine motor shall operate on 110 volts DC. The motor shall be the split-field winding type or if permanent magnet type, shall be equipped with suitable devices which will prevent the motor from being operated by stray or transient voltages. Armature brushes shall be accessible by the removal of a single access cover.

6. Manual Operation: Switch-and-lock movements shall provide for manual operation by a removable hand crank or hand throw. Self-contained circuits shall open the motor circuits and prevent electrical operation of the switch-and-lock movement during manual operation.

7. Hand Crank Mounting: The hand crank shall be mounted to the side of the switch-and-lock movement when not in use.

8. Restoring Feature: The switch-and-lock movement and its associated operating circuits shall be configured with a restoring feature. The restoring feature shall cause the switch-and-lock movement to return to its original position if the auxiliary switch call is changed while the switch machine is in transition or mid-position. Restoring the switch-and-lock movement to power after hand-cranking for less than eight seconds shall cause the restoring feature to be effective. After hand cranking for eight seconds or more, the restoration feature shall be disabled by a timer. To enable restoration, the switch shall be called first to the position opposite its original position to reset the timer then called to its original position.

9. Controller: Switch-and-lock movements shall include an integral circuit controller which shall indicate the switch position when the points are fully closed and locked by the lock rod in the normal and reverse positions. Separate point detection shall be provided for each switch point.

10. Method of Furnishing Rods: All rods shall be furnished to the proper length, threaded, and machined for on-site installation. Lock and throw rods shall be covered with a black 3/32-inch, heat-shrinkable insulating sleeve that shall be shrunk in place. Detector rods for both switch points shall be provided with an insulated section as indicated. All machined surfaces shall be packaged for protection during shipping and handling.

11. Insulation: Switch-and-lock movements shall be insulated from the rail by an insulated section in each rod and gauge plate. The insulation shall be capable of withstanding a test voltage of 1,500 V ac for not less than three seconds, without flashover or puncture between all metallic parts.

12. Rod Bends: The main portion of all rods shall be straight, except for bends permitted at the ends to facilitate connections.

13. Dimensions: Switch-and-lock movements shall be used with track having a gauge of five feet and six inches. Points shall have a 4 3/4-inch throw. Switch-and-lock movements shall be designed for application with steel rail at 119 pounds per yard. Points shall not be less than 16 1/2 feet, nor more than 39 feet in length.

B. Derails: Derails shall be provided at locations indicated on the Contract Drawings, complete including switch-and-lock movements, indicators, bell cranks, rods, cable, and all installation hardware. Derail Indicators shall be provided at all derail locations. The indicator light aspects shall be FAA green and AREMA Standard red. Each assembly shall include two Taxiway Centerline light units with bi-directional apertures as manufactured by Crouse-Hinds Airport Lighting Products 852NF-65W, or District approved equivalent. Product information shall be submitted to the District for approval.

1. Derail indicators shall display the following aspects:

Aspect	Indication	Functional Characteristic
Red	Stop	Derail not clear (up)
Green	Clear	Derail clear (down)

2. The light units and transformers shall be mounted in a single indicator enclosure with removable cover made of 10 gauge steel, hot-dipped galvanized after fabrication and painted flat black.

3. Encapsulated step down (120V - 9V) transformers shall be provided as required. An in-line adjustable resistor shall be provided in the high voltage side of the transformer circuit (preferably in the switch junction box) to adjust lamp voltage for extended lamp life.

4. The indicator shall be installed between the running rails not closer than 48 inches in approach to the derail throw rod and not interfering with any other signaling apparatus.

5. The indicator assembly shall be directly energized and controlled from its corresponding derail switch machine. Derail number plate shall be mounted on front and back of indicator assembly box.

C. Wayside Signals: Wayside signals shall be provided at locations specified herein and as indicated on the Contract Drawings. All signals, brackets, poles, concrete foundations, and hardware required to mount the signals shall be furnished. All signals shall be complete, equipped with lamps, lamp receptacles, lenses, resistors, transformers, terminals, number plates, masts, and bases, as required. The signals shall, insofar as possible and practicable, be assembled and wired at the factory. Signal heads, after installation, shall be covered with durable opaque bags or other approved methods to prevent visibility of the signal aspects. The bags shall be removed during testing and reinstalled at the end of each test. The bags shall remain in place until the District authorizes their removal. Product information for all types of wayside signals shall be submitted for approval.

1. General: Fixed signals and route indicator signals shall meet the following requirements.

   a. Fixed Signals: Fixed signals shall be single lens color light signals capable of providing from one to four different color indications, as indicated. Fixed signals shall be located on the right-hand side at gates governing entry to a route.

   b. Route indicator signals shall be two aspect color light signals with masks as shown on the Contract Drawings. Route indicator locations with their corresponding masks shall be as indicated on the Contract Drawings. A route indicator aspect shall be illuminated when the corresponding route is aligned and locked.

2. Electrical Illumination: Signals shall be electrically illuminated without mechanical movement of any kind. Signal aspects shall be generated utilizing light transmitted from individual lamp-filter modules to a single common output lens by use of fiber optic cable.

    a. Lamps: Signal lamps shall be LED with SC bayonet base. Bulb life shall be rated 1,000 hours. Lamps shall conform to the requirements of AREMA Signal Manual, Part 14.2.1.

    b. Signal Power: Power for signals shall be supplied from the 120V Essential Power bus in the train control equipment rooms. All necessary cables, conduits, transformers, rectifiers, switches, overload protection, and accessories required for distributing power for signals shall be furnished.

3. Readability: Signals shall be designed to avoid reflection of light from an exterior source and shall be readable from the Transit Vehicle operator's position at a distance of 250 feet for main line signals. Signals shall be readable under adverse environmental conditions at distances ranging from 250 feet to 5 feet in approach to the signal.

4. Cone of Visibility: The cone of visibility shall be such that it complies with the requirements, as indicated, and shall be sufficiently side shielded to avoid projection of confusing aspects from signals on adjacent tracks.

5. Resistor: Signals shall be furnished with one independently-mounted, voltage-adjusting resistor for each aspect. Lamps and accessory equipment in the signal power circuit shall be rated to operate at the same voltage and current.

6. Type: The signal type shall be as indicated. Maintenance of the signal shall be possible from the back or side of the unit. Cable entry shall be through the unit base.

7. Exposed Surface: The exposed surface of the signal lens outer unit shall be smooth and shall develop neither checks nor cracks, nor deform with age.

8. Signals shall be furnished with screened ventilators.

9. Chromaticity: Chromaticity shall comply with either AREMA or IES Standards.

10. Doors: Signals shall be provided with a hinged door capable of being locked with a padlock. A padlock shall be provided for each door and shall be fastened to the signals with a nine-inch bronze sash chain. The door shall not be lockable unless the door is fully closed.

11. Shipping: Lamps shall be shipped separately from the signal heads to avoid breakage.

12. Alignment: The signals shall be aligned and focused, horizontally and vertically, to obtain the sighting distances specified.

13. AREMA Standards: Wayside signals shall conform to all requirements contained in the AREMA Signal Manual, Part 7.1.1, Sections 6 through 16 and 18 through 21.

D. Rail Connections: Cable to rail connections shall be made by drilling and pinning as indicated. Product information for rail connections shall be submitted to the District for approval. Specific product requirements shall be as indicated.

1. Track Circuits: Track circuit connections including all connections to impedance bonds and rails shall be provided as required for ATC purposes.

2. Switch and Track Bonding: Frog assemblies and switch points shall be connected by bonds to the running rails. Rail mechanical joints, if implemented, shall be bonded. Other electrical bonding for ATC purposes shall be provided, as required, using the materials and methods as indicated in the Contract Drawings.

3. Cross Bonding: Cables required for cross bonding between adjacent tracks shall be provided and connected.

   a. Cross bond cables shall be as specified in Section 34 42 16, Train Control Wires and Cables.

   b. Connections and number of cables shall be as indicated in the Contract Drawings.

   c. Cross bonding cables between adjacent tracks shall be installed in conduit.

4. Negative Returns: Substation negative return cables to impedance bonds or track shunts shall be connected as indicated in the Contract Drawings.

5. Gap Breaker Negative Connection: A gap breaker negative connection to impedance bonds or track shunts shall be connected as indicated in the Contract Drawings.

   a. Negative connections and connecting hardware shall be provided by the Contractor as described above for negative returns.

   b. Additional No. 6 AWG voltage sensing cables shall be connected to the running rails with pin bonds as specified in Section 34 42 16, Train Control Wires and Cables.

E. Conduits, Cable Trenches, and Accessories: Conduits, cable trenches and accessories shall be furnished as required for wayside ATC equipment. Layout drawings showing conduit arrangement shall be submitted for approval.

F. Switch Power Supply Cabinets (SPSC): SPSC's shall be NEMA 4X, weather tight enclosures and shall be equipped, arranged, and wired as specified. SPSC's shall be installed at interlocking locations which shall be indicated in the contract drawings.

1. Power: SPSC's shall receive 480-volt ac single phase power from the adjacent train control room/house. The contract Drawings shall provide connection details.

2. Transformers: Each SPSC shall include a 480-volt to 120-volt stepdown transformer with taps. The transformer enclosure shall be NEMA 4X.

3. Surge Suppression: A single phase transient voltage surge suppressor, Eaton, CVX100-480L or equal, shall be provided for protection of service entrance and distribution.

4. Ground Detector: Ground detectors shall have the sensitivity to detect a minimum ground leakage resistance from the ac supply bus per NEC 250.21(B), NEC 250.167(A), and CEC 10-400. Acceptable Product: Bender ISO685 or equal.

5. Automatic Transfer Switch: An automatic transfer switch shall be provided for locations that have an alternate power feed. Contract Drawings shall provide specific details.

6. Wiring: 120-volt ac power shall be wired from the SPSC to each switch machine and maintenance receptacles as indicated. Intra-cabinet wiring including interior components shall not use twist-on wire connectors (wire-nuts) and shall be connected or terminated in accordance with this Section and Section 20 70 26 Common Materials and Methods for Electrical Systems.

7. Lighting: SPSC shall be provided with light switch and LED lighting equivalent to 100 Watts of incandescent lighting at the top of the cabinet.

8. GFI: SPSC shall be equipped with GFI receptacle.

9. Termination: switch machine wiring shall be terminated in accordance with AREMA standards.

10. Eyes: The cabinet shall be equipped with stainless steel lifting eyes sized to support lifting the cabinet fully equipped and wired.

11. Foundation: Provide cast in place foundation for each SPSC, as indicated. Precast foundations may be used if approved by the Engineer.

12. Finish: The cabinet shall be hot-dipped galvanized and shall receive the manufacturer's standard shop primer paint coat. Scratches in the prime coat or finish coat shall be repaired following installation. Cabinets in known corrosive areas shall be constructed of stainless steel or other non-corrosive materials.

    a. Zinc coatings that have been damaged in handling, transporting, welding, riveting, or bolting shall be repaired by the application of a thick paste made from galvanizing repair compound conforming to MIL Spec. P-21035, 2 coats of 2 mils dry film thickness per coat. Areas to be repaired shall be cleaned thoroughly, including removal of slag on welds, before paste is applied.

    b. The cabinet shall receive a finish coat of exterior paint, in accordance with the requirements, indicated in Section 09 91 00, Painting.

    c. The concrete foundation pad surface shall be free of paint when painting is completed.

13. Doors: Provide cabinet doors with hinges, three-point (top, middle, bottom) lockable hasp capable of being locked with a padlock. Cabinet doors shall be provided with corrosion resistant ventilating louvers. Doors shall open at least 120 degrees with holding position hooks and clips.

14. Pocket Holder: Provide a pocket holder on the inside of the front door of each SPSC. Place terminated copies of the SPSC operating manual and plans in the pocket holder.

15. Ventilation: Contract Drawings shall indicate ventilation details.

16. Ground: Contract Drawings shall indicate cabinet grounding details.

17. Spares: Contract Drawings shall indicate spare terminal detail.

18. Identification Plate: Contract Drawings shall indicate SPSC Identification Plate details.

19. Wire Tags: Wire identification shall be in accordance to Section 34 42 16 Article 3.02 Train Control Wires and Cables.

2.03 FIXED BLOCK ATC SYSTEMS

A. Track Shunts and Impedance Bonds: Track shunts and impedance bonds required for the ATC System, including all mounting hardware, connectors, cable, and other appurtenances shall be furnished, installed, and tested. Track shunts and impedance bonds shall be installed at locations as indicated. Product information for shunts and impedance bonds shall be submitted for approval.

1. Functions: Track shunts, impedance bonds, and tuning units shall be assembled in units and installed between the running rails. Shunts and bonds shall provide a traction power current return path from running rails to cross-bond or substation negative connections and around insulated joints. In audio frequency track circuit applications, shunts and bonds shall also couple track signals between running rails and transmitters or receivers.

2. Performance Requirements. Track shunts, impedance bonds, and associated cabling and connections for audio frequency applications shall be designed to carry a minimum of 2,500 amperes per rail continuously, and peak currents at three times the continuous rating for one minute.

    a. Shunts and impedance bonds shall function properly with traction current imbalance of 12 percent and ripple current imbalance of up to 30 percent of the per-rail current capacity. Shunt or bond dc resistance between track winding terminal lugs shall not exceed 0.0003 ohm for power frequency bonds, and 0.00008 ohm for audio frequency bonds as measured with a Double Kelvin bridge. Current imbalance of the rails is defined as the ratio of the larger current in one rail to the smaller current in the other rail minus one.

3. Rail Connections: Track shunt and impedance bond track windings shall be provided with a minimum of two terminal lugs per rail, each of which shall accept two 500-kcmil cables.

    a. At impedance bond layouts which define track circuit limits, provide a minimum of two 500-kcmil cable connections to each rail.

    b. At impedance bond layouts providing connection to substation negative returns, or providing propulsion current path around insulated joints, provide a minimum of four 500-kcmil cable connections to each rail.

4. Center-tap Connections. Shunts and impedance bonds shall also be provided with one center-tap adapter plate for back-to-back bond, cross bond, or substation return connections.

    a. Center-tap adapter plate shall be copper silver plated at connection areas and shall have current and connection capacity required for its particular application. Cable connections to center taps shall be tin-plated, or approved equivalent.

    b. Center-tap adapter plate shall accommodate connections of 500 and 750 kcmil cables as indicated.

    c. Shunt or impedance bond center taps shall be used:

        1) To terminate cross-bonding cables.

        2) To connect neutral cables between impedance bonds on same track at insulated joints.

        3) To terminate substation negative return cables.

    d. Connectors: Watertight plug connectors shall be used for external connections to the tuning unit and for connection to the shunt or bond from the tuning unit.

    e. Installation: Shunts, impedance bonds, and tuning units shall be sized to facilitate mounting between running rails on all types of roadbed without any part extending above the top of rail. Shock mounting shall be provided to offset the effects of track vibration. Assemblies shall be isolated from ground.

B. Insulated Joints: Insulated joints shall be provided at gates in crossovers and turnouts in the interlocking areas. Additional insulated joints shall be furnished as required to meet Contractor’s ATC system design.

PART 3 – EXECUTION

Not used

END OF SECTION 34 42 25

SECTION 34 50 10

FARE COLLECTION SYSTEM

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Fare media

B. Environmental requirements

C. Equipment requirements

D. Software

E. Data communication interface

1.02 RELATED SECTIONS

A. 26 05 26, Grounding and Bonding for Electrical Systems

B. 26 05 70, Electrical Cabinets and Enclosures

C. 34 50 11, Fare Collection Equipment Installation

D. Appendices, District Technical Manuals, BART Ticket Specifications

1.03 MEASUREMENT AND PAYMENT

A. General: Fare collection system, as specified herein, will not be measured separately for payment but will be paid for as part of the Contract lump sum price for the related item of work in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. International Electronics Commission (IEC):

1. IEC-61000-4-2 Electromagnetic Compatibility (EMC) – Part 4-2: Testing and Measurement Techniques- Electrostatic Discharge Immunity Test

2. IEC-61190-1-1 Attachment Materials for Electronic Assembly – Part 1-1: Requirements for Soldering Fluxes for High-Quality Interconnections in Electronics Assembly

3. IEC 60512-12-5 Connectors for Electronic Equipment – Tests and Measurements – Part 12-5: Soldering Tests- Test 12e: Resistance to Soldering Heat, Soldering Iron Method

B. Military Specifications (MIL):

1.	MIL-STD-461	Requirements for Control of Electromagnetic Interference, Characteristics of Subsystems and Equipment

C. International Organization for Standardization (ISO):

1.	ISO/IEC 7811-2	Identification Cards Recording Technique, Part 2: Magnetic Stripe-Low Coercivity
2.	ISO/IEC 7811-6	Identification Cards Recording Technique Part 6: Magnetic Stripe-High Coercivity
3.	IEC 61000-4-2	Electromagnetic Compatibility (EMC) Part 4-2: Testing and Measurement Techniques-Elastrostatic Discharge Immunity Test

D. Underwriters Laboratory, Inc. (UL):

1.	UL 437	Standard for Safety Key Locks

E. American With Disabilities Act (ADA):

1. American with Disabilities Act Accessibility Guidelines (ADAAG)

F. California Code of Regulations (CCR):

1.	Title 24	Building Standard Code

G. National Fire Protection Association (NFPA):

1.	NFPA 70	National Electrical Code (NEC)
2.	NFPA 101	Life Safety Code

H. American Society of Testing and Materials (ASTM):

1.	ASTM A240/ A240M	Standard Specification for Chromium and Chromium-N Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
2.	ASTM A480/ A480M	Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
3.	ASTM A1008/ A1008M	Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable
4.	ASTM C920	Standard Specification for Elastomeric Joint Sealants

5. ASTM D3951 Standard Practice for Commercial Packaging

I. American National Standards Institute (ANSI)

J. International Organization for Standardization (ISO)

K. Association Connecting Electronics Industries (IPC):

1. IPC 2221B Generic Standard on Printed Board Design
2. IPC 2222A Sectional Design Standard for Rigid Organic Printed Boards

L. San Francisco Bay Area Metropolitan Commission (MTC):

1. Clipper® Card Specification

1.05 DESCRIPTION

A. General: Automatic Fare Collection items of equipment include the following:

1. Ticket Vending Machines (TVM)
2. Fare Gates
3. Addfare Machines (AFM)
4. Bill to Bill Changers
5. Intermodal Transfer Machines
6. Paid Parking Machines
7. Cash Carts
8. Treasury Vaults

1.06 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Submit the following:

1. Conceptual Design Submittal:

a. General description of the major sub-assemblies including identification of components supplied by subcontractors for each type of equipment.

b. Preliminary internal layout of sub-assemblies for each type of equipment.

c. Preliminary layout of the front operating panels for each type of equipment.

d. Functional block diagram of the system and equipment.

e. Catalog cuts of the following modules: Customer Interface Module including Main Display Unit, soft keys and numeric keypad; bill validator, bill escrow, and bill vault; coin system; smart card interface device; credit/debit card module and the equipment CPU.

f. Outline and format of customer interface messages.

g. Identification and description of interfaces between the major sub-assemblies.

h. Identification and description of interfaces between the Automatic Fare Collection (AFC) equipment and the existing station equipment including Data Acquisition System (DAS) interfaces, as well as Engineering Maintenance Equipment (EME) interfaces where applicable.

i. Identification and general description of functions, data elements and messages to be supported by the Vending Equipment Interface (VEI) communications protocol and DAS.

j. Information and decisions required from the District.

k. Physical dimensions of each type of equipment.

l. Power and other facility requirements of each type of equipment.

m. Plans, programs and other data related to management, training, manuals, quality assurance, reliability assurance and configuration control.

2. Preliminary Design Submittal

a. Detailed technical description of operation for major subassemblies in units of equipment.

b. Complete customer interface drawings, flow charts, screens graphics, messages and menus, including accommodation of operating boundary and error conditions.

c. Voice database.

d. Sample tickets with encoded magnetic stripe.

e. Software flow charts down to three levels of detail.

f. Hard-wired communication interface.

g. A detailed description of the DAS/EME interface including:

1) Identification and detailed description of VEI dialogs required to meet the network functionality of the AFC equipment. The description shall include the structure, format, content, sequence, and timing of the dialogs.

2) Identification and detailed description of data items, data values, and control functions to be implemented in the VEI communication protocol and DAS/EME to meet the operational and data reporting functionalities

of the AFC equipment. The description shall include the format and value of the data elements and control functions.

3) Identification and description of VEI protocol layers (i.e., Transport, Session) required conforming to the AFC equipment network functionality.

h. Single line power diagrams, control schematics, and functional block diagrams for each subsystem.

i. Evidence of operational and physical compatibility with the existing equipment and equipment installations.

j. Design of the access control to the equipment and to the software menus.

k. Plans, programs and other data including front panel Human Factors evaluation and draft screen flow charts and display messages.

l. Faregate ticket processing algorithms.

3. Final Design Submittal

a. Latest revisions of the drawings, documentation and samples that were submitted at the CDR, PDR and MDR.

b. Complete production drawings for each type of equipment

c. Electrical schematic drawings, down to the individual signal and component level.

d. Complete baseline software and preliminary software documentation for each type of equipment.

e. Fully operating ticket handling mechanism

f. If applicable, demonstrated compatibility of BART tickets encoded by the new equipment with existing system.

g. If applicable, demonstrated compatibility of new equipment with tickets encoded by existing equipment.

h. List of maintenance service commands, codes and messages.

i. Fully operating smart card components.

j. Plans, programs and other data.

k. Latest revisions of the DAS/EME interface description submitted at PDR.

C. Equipment Mock-up Arrangement.

D. Operations and Maintenance Data: Submit maintenance data and operating instructions in accordance with Section 01 78 23, Operations and Maintenance Data.

E. Training: Submit training for BART technicians (e.g. on installation) and engineers (e.g. on software) in accordance with Section 01 79 00, Demonstration and Training.

F. Test Reports: Submit certified factory and field test reports.

1.07 QUALITY ASSURANCE

A. General: Refer to Section 01 43 00, Quality Assurance, and Section 01 45 00, Quality Control, for general requirements.

1.08 EXISTING SYSTEM DESCRIPTION

A. General: The existing automatic fare collection equipment is a stored-value, distance-based system. The system is a closed-barrier type which requires fare media (magnetic stripe tickets or Clipper® cards) for both entry and exit. Depending on the ticket type, the ticket value can range from $0.05 to $315.00 in $0.05 increments. Fares as of 2018 range from $2.00 to $16.65 depending on trip length and fare product/media type. Statistical, performance and financial data from the AFC equipment are collected via the DAS. The DAS consists of hardware and software, with the central host computers at a central location. AFC equipment is connected within the station by local area networks (LAN). Multiple VLANs may be used in each station to segregate traffic for PCI compliance. LANs and central computers are connected together by a wide area network (WAN). Configuration management and software/parameter downloads are performed via the Engineering Maintenance Equipment (EME) platform, consisting of server equipment at a central location.

B. Fare media/Equipment Process. Both magnetic stripe tickets and smart cards with integrated circuits are supported. The District is transitioning to 100 percent smart card usage. Both tickets and smart cards are of credit card size. Information necessary for passage are encoded on the magnetic stripe or the smart card memory. The AFC equipment reads and writes information on the stripe or integrated circuit, as necessary.

Specific equipment types include:

1. Ticket Vending Machines (TVMs) are located in the free areas of stations. The TVM accepts coins, bills, and credit and debit card as payment and issues a ticket or smart card for the amount selected; it encodes the fare media for entry.

2. Fare gates are located to separate the free and paid areas of stations. The entry gate establishes the station of origin and other control information for a particular trip; it encodes the fare media for exit. The exit gate subtracts the fare from the stored value based on the entry station.

3. Add fare machines (AFMs) are located in the paid areas of stations. The addfare machine accepts cash payment only and allows value to be added to certain tickets if the remaining value is less than the required fare at exit. The District is moving towards supporting credit and debit cards on the AFMs. Additionally, the AFM accepts payment for parking.

4. Bill to Bill Changers (BBC) are located in both free and paid areas. The BBC accepts $20 and $10 bills and returns 4 x $5 bills or 2 x $5 bills in return.

5. Parking Validation Machines (PVM) are located in paid areas at stations where parking validation is required. Customers with smart cards associated with pre-registered accounts can tag their smart card to validate parking.

The AFC equipment is designed to handle multiple ticket formats and smart cards as specified in Article 2.01 herein.

C. Generations of Equipment. Prior to 2002, there were three generations of existing equipment. The first- generation equipment was provided by IBM in 1972-1973. The second-generation equipment was provided by Cubic Western Data (Cubic) in 1974-1975. The third-generation equipment was provided by Scheidt and Bachmann GmbH (S&B) in 1995-1997. Functionally, the Cubic equipment is virtually identical to the IBM equipment, except that change can be returned from the ticket vendors and addfare machines when a ticket transaction is involved. The second-generation equipment was enhanced primarily for treasury activities such as bulk loading coin hoppers and bill stackers. Dedicated money changers located in both the free and paid areas of each station provide change for the IBM equipment. IBM and Cubic TVM and AFM accept bills and coins for payment and issue BART Blue tickets only. The S&B equipment includes TVM, AFM and fare gates in the five recently opened stations, and Credit/Debit Vendors (C/DV) in 20 of the original 34 stations. The S&B TVM accept bills, coins, credit or debit card for payment and give change. The AFM accept bills and coins for payment and give change. The S&B Credit/Debit Vendors accept bills and credit or debit cards for payment. S&B's TVM and Credit/Debit Vendors issue BART Blue and BART-Plus tickets.

Under AFC Modernization program contract 47BC-110, fare collection equipment systemwide, including TVMs, AFMs and fare gates were replaced in 2003 with equipment provided by Cubic Transportation Systems (CTS). The equipment delivered by CTS and subsequently modified by either CTS or the District included the following functionalities:

1. (TVM/AFM) Accept bills and coins for payment.

2. (TVM only) Accept credit and debit cards for payment.

    a. Future plan to accept credit and debit cards on AFMs.

3. (TVM only) Dispense BART Blue Tickets.

    a. In 2008-2009, all TVMs were modified to dispense high-coercivity high-density serialized tickets.

    b. BART Plus capabilities were originally included but disabled in December 2015 at the conclusion of the program.

    c. In 2017, selected TVMs were retrofitted to dispense Clipper® cards. Magnetic ticket capabilities are not available on these retrofitted TVMs.

4. (TVM/AFM) reload value on Clipper® cards

5. (Fare Gates) accept magnetic stripe ticket, BART Only Smart Cards (BOSC) and Clipper® regional smart cards for entering and exiting the BART system.

6. (AFM only) accept coins, bills and ticket for parking payment and validation.

   a. Future plan to accept credit and debit cards on AFMs.

   Subsequently in 2008, Parking Validation Machines (PVMs) procured under contract 47BC-110 were installed to accept BART Only Smart Cards for back office account-based parking payment. This functionality was extended to Clipper® cards in 2010.

   A new generation of equipment was procured in 2012 for the opening of new extension stations, including Oakland Airport Connector, Warm Springs, Silicon Valley extension and eBart extension to Antioch. These were procured as Designating Matching Product (DMP) matching the functionality of existing equipment, upgraded to address component obsolescence.

   All CTS equipment procured under contract 47BC-110 were retrofitted in 2016-2017 in order to address equipment obsolescence and upgrade to match those provided for extension stations including Warm Springs and Silicon Valley extension station.

   Also in 2002, Bill to Bill Changers (BBCs) were procured and deployed to all stations systemwide. These were field-retrofitted in 2016 with updated components to address component obsolescence. A new generation of BBCs were constructed in 2015-2016 for deployment to extension stations.

1.09 DESIGN REVIEWS

A. Design reviews will be conducted by the Engineer to evaluate the progress and technical adequacy and conformance of equipment design with Contract requirements. Each design review shall include a design review submittal and a design review meeting. For each design review, a design package shall be submitted that includes documents listed. The District will review the documents and discuss its comments during the design review meeting. The design review meeting will be scheduled by the Engineer approximately two weeks after the design review submittal has been received by the Engineer. District comments shall be incorporated on the next design review submittal. Design reviews shall occur in the following chronological order:

   1. Conceptual Design Review. The conceptual design review (CDR) shall evaluate system concept and design approach and discuss District's comments on the conceptual design package submittal.

   2. Preliminary Design Review. The preliminary Design review (PDR) shall evaluate further the progress and adequacy of the equipment and contract requirement compliance. District's comments on the preliminary design review package submittal shall also be discussed during the PDR.

3. Mock-up Design Review: The mock-up design review (MDR) shall evaluate the actual layout of the equipment and samples of selected modules and assemblies. The MDR shall include at least the following items:

    a. Mock-ups shall be implemented with real equipment. If real equipment is not available, the mock-ups shall be implemented using full size, colored, and scaled drawings of each piece of equipment, including exterior and interior. The drawings shall be mounted on plywood or foam core panels for “touch and feel” evaluation by the District.

    b. Samples of the following modules: Message Display Unit, numeric keypad, keys, bezels, coin return cup, bill validator/escrow/box, bill dispensing device, bill cassette, coin system, money containers, ticket handling system, credit/debit module, voice module, smart card module, locks. For gates: operating barrier, customer displays.

    c. Presentation of front panel layout and operation, including screen flow charts and display messages.

4. Final Design Review. The final design review (FDR) shall evaluate the detail design and the production drawings for the equipment. The FDR is the mechanism for determining whether the detailed design has a high probability of meeting all the design requirements, subject only to the results of any following tests or audits such as the pre-production tests, the reliability test during revenue service, and reliability and data accuracy audits.

5. Pre-Production Review. The Pre-Production Review (PPR) shall evaluate actual operation and performance of the pre-production equipment in an in-service environment.

    The PPR shall provide the basis for the Engineer’s release of manufacturing of the production equipment. Pre-production equipment approved as noted shall be the Production Configuration Baseline. Changes to the Production Configuration Baseline shall be controlled by an Engineering Change Proposal covered in a Configuration Management Program.

    The PPR shall include at least the following items:

    a. Fully operating units for each type of equipment in the quantities and locations indicated.

    b. All interfaces fully operating.

    c. All software and firmware fully operating.

    d. Customer Interface Finalized.

    e. Cash carts, special tools and test equipment in the quantities and locations indicated.

6. Equipment Placement Details Review: The Equipment Placement Details Review (EPDR) shall be held to evaluate the placement details and resolve issues resulting from the District’s review of placement drawings and documents. The EPDR shall evaluate at least the following items:

a. Physical mounting items, including base plates, lifting procedures, and filler panels for each type of equipment;

b. Electronic/electrical interfaces; and

c. Installation/cutover plan.

1.10 PACKAGING, HANDLING, TRANSPORTATION, AND DELIVERY

A. Standards. Packaging, handling, transportation, and delivery of AFC equipment shall conform to ASTM D3951, NMFC, and UFC standards.

B. Packaging, handling and delivery of credit/debit card readers and PIN pads shall follow all procedures required by PCI (Payment Card Industry) and PIN audit, including the following:

1. Use of tamper evident tape when shipping.

2. Provide logs of proof of tracking and delivery notices.

3. Provide inventory with serial number tracking and disposition of each device.

PART 2 – PRODUCTS

2.01 FARE MEDIA

A. Ticket Processing: AFC equipment shall be designed to accommodate magnetic stripe tickets manufactured in accordance with the BART ticket specifications indicated in District Technical Publications; BART Ticket Specifications; and shall process tickets in the same manner as the existing AFC equipment.

B. Ticket Reading and Encoding: AFC equipment shall be designed to process tickets encoded to the District specifications, Ticket Encoding and Reading Specifications, and shall meet the following requirements:

1. Read and verify data only from track 2 of magnetic stripes that conform to the stripe width specification of ISO/IEC 7811-2, Magnetic Stripe – Low Coercivity, and ISO/IEC 7811-2, Magnetic Stripe – High Coercivity.

2. Write full width on magnetic stripes that conform to the stripe width specification of ISO/IEC 7811-2 and 7811-6.

3. Capable of being easily modified to read/verify and write tickets with data densities of either 120 bits per inch or 190 bits per inch in an intermixed fashion in the same ticket handling mechanism.

4. Write starting at a predetermined position on the magnetic stripe; and

5. Write at a five-degree angle.

6. Supplier shall provide the design details for the algorithm used by the AFCE to find valid data records from the read-in ticket data for District review and approval during PDR.

C. Ticket Formats: Magnet tickets, shall support the encoding of information such data as station of origin, time, ticket type, remaining value and serial number where possible on the ticket. Detailed information on ticket formats will be provided to the Supplier after Contract Award and upon execution of a confidentiality agreement. AFC equipment shall support the following ticket formats:

1. Low-density (120-bpi) tickets with the following ticket types:

   a. BART Blue Ticket: Basic ticket used by the majority of BART customers. It is valid only on BART. The ticket value can range from $0.05 to $79.95 in $0.05 increments. It is not time-limited.

   b. BART Red Ticket: Discount ticket for disabled and youth. It has the same encoding format as the BART Blue Ticket except for the ticket type code.

   c. BART Green Ticket: Discount ticket for Senior Citizens. It has the same encoding format as the BART Blue Ticket except for the ticket type code.

   d. Student Ticket: Discount ticket for students. It has the same encoding format as the BART Blue Ticket except for the ticket type code.

2. Universal format tickets, which has a higher-density encoding capable of storing more data including ticket serial number. Ticket types supported on the universal ticket format shall include the following:

   a. BART Blue ticket, unrestricted fares

   b. BART Red ticket, disabled and youth

   c. BART Green ticket, seniors

   d. BART Orange ticket, students

3. BART fare gates shall support BART-Only Smart Card (BOSC) with the following fare types:

   a. BART employees, Dependents, Retirees, Contractors

   b. Law Enforcement Officers (LEOs)

   c. Qualified discount programs including airline/Airport Employee programs for San Francisco International Airport and Oakland International Airport

4. Regional Clipper® fare payment media, supporting the following fare products:

   a. Regional e-purse for adult, youth, senior, disabled fare categories

   b. BART High Value Discount (HVD) purse

   c. Muni Adult Fast Pass “A” (for BART stations within San Francisco only)

2.02 ENVIRONMENTAL REQUIREMENTS

A. General: AFC equipment shall be designed to conform to the environmental requirements specified herein. The Supplier shall be responsible for acquiring data on pertinent conditions that exist at the sites and shall assure by test, analysis, or field records that the AFC equipment operate properly under these conditions. AFC equipment shall be designed in accordance with IEC 61000-4-2 and MIL STD 461.

B. Electrical Environment. AFC equipment shall be immune from electromagnetic interference and electrostatic discharge. Transmission from the AFC equipment, either radiated or conducted, shall not cause interference to other systems within the BART system or other nearby systems. The Supplier shall provide certification of all tests conducted in accordance with accepted standards and provide details of the test and test results. Existing analysis and data on EMI susceptibility and EMI conductive or inductive radiation of the proposed equipment, properly documented and verifiable applications that are identical may be used for this purpose.

1. Definitions

    a. Electromagnetic Compatibility (EMC) is defined as the proper operation of AFC equipment and sub-systems in the presence of potentially interfering electromagnetic noise or signals from other sub-systems such as traction power or communications, or from the ambient Electromagnetic environment of the District system.

    b. Electromagnetic Interference (EMI) is defined as interference generated by the AFC equipment on other equipment such as the communications system, signaling system, or any equipment located within the District's stations.

2. EMC Program. An EMC Program shall be submitted for approval during the Final Design Review. The Supplier shall apply the EMC program requirements to all equipment systems and subsystems. All equipment, whether taken individually or in groups, shall comply with the EMC requirements for all modes of operation. The Supplier shall work with the District and other equipment suppliers to resolve any EMC problems discovered during execution of the Contract. The Contractor shall conduct an Electromagnetic Compatibility (EMC) Program consisting of the following elements:

    a. Determination of the District's EMC environment.

    b. Analysis of the EMC design characteristics, emissions, susceptibility, and margin of AFC equipment.

    c. Analysis of EMC impacts.

C. Temperature and Humidity. AFC equipment shall function normally between an ambient temperature range of 10 degrees Fahrenheit to 122 degrees Fahrenheit and in a relative humidity range of 5 percent to 95 percent, non-condensing. The equipment shall be tested at the limits of the realistic combinations possible between temperature and relative humidity and at the primary voltage tolerances of plus and minus 10 percent. Performance shall not be affected by any increase in internal temperature caused by the rigors of the test program, such as constant cycling over long time periods.

1. The AFC equipment shall function normally within the ambient maximum temperature while exposed to direct sunlight for up to eight hours.

2. The AFC equipment shall be sealed and protective compounds used for sensitive internal components to avoid an increase in the humidity or potential damage to the inside of the AFC equipment that could be caused by salt laden fog, water seepage through the concrete from water sprinklers, floor scrubbers and devices existing in the operating environment.

D. Noise. AFC equipment shall not cause a sound pressure level, above the ambient, of more than 65 db on the “C” scale at 3.0 feet in any direction except audible prompts or messages.

E. Seismic Protection. No equipment, rack, assembly, module nor component shall become loose, nor shall it fail to meet operating requirements, after being subjected to a gradually applied force equal to 0.25 times its weight applied in any direction approximately through its center of gravity or seismic loading equivalent to 1.5 g horizontal and 1.0 g vertical acceleration, whichever is more severe.

F. Shock and Vibration. The Supplier shall verify that the shock and vibration limitations of the equipment or any part of the equipment are not exceeded. The design and construction of the equipment shall be such that the usual shock and vibration levels experienced during transportation by rail, truck or airplane shall have no damaging effect on the equipment. This assumes that no special precautions are taken other than solid anchoring of the cabinet and special packaging internally to prevent damage. After placement, the equipment shall operate normally under the following conditions:

1. Continuous vibration at a frequency range between 0 and 6 Hz and at an acceleration level up to .01 g.

2. Intermittent shocks of up to 0.1g, not exceeding 20 millisecond durations, half sine wave, and repeated at intervals of 0.5 to 2.0 seconds.

G. Dust: AFC equipment shall maintain normal operation when exposed to Eolian particles, including brake shoe dust and normal dust present in a rail system environment, both abrasive and non-abrasive, including electrically conductive dust and salt-laden air. Suitable enclosures shall be provided inside the equipment for sensitive components such as printed circuit boards and memory storage device to prevent abnormal operation resulting from dust particles that could be as small as 1 to 200 microns, with a maximum concentration of 0.248 mg/cm3. Where possible, positive air pressure shall be used to reduce the dust intake. Filters shall be used where positive air pressure is not adequate to block the entry of dust particles as described above.

H. Exposure to Sunlight. Measures shall be taken to minimize the effects of direct sunlight on the ticket vendors, addfare machines, and gate consoles. The use of sculptured buttons, high intensity light, surface grain depth and direction shall be employed to enable easy readability and operation in order to minimize the time for a transaction. In order to minimize problems caused by solar heat or bright light, the Supplier shall consider the following factors in the design: selecting components with

a storage temperature range at least 20 degrees Fahrenheit above the maximum working temperature expected; turning on fans automatically; using tilt angled surface orientation, texture, and covers to reduce reflections and glare; using graphics and display types that are readable under all natural and artificial light conditions. Components sensitive to ultraviolet and visible light radiation shall be protected at all times, and the equipment shall be resistive to damaging effects from this type of radiation, including when the front door is open for maintenance and servicing activities.

2.03 EQUIPMENT REQUIREMENTS

A. Compatibility: Automatic fare collection equipment shall be compatible with and function as an integral part of the existing AFC system. Compatibility factors shall include, but not be limited to the following:

1. Provisions for purchasing tickets and Clipper® cards, upgrading tickets and reloading Clipper® cards using credit or debit cards.

2. Money collected or used for re-supply shall be contained in locked metal boxes.

3. Use of microprocessors for control of individual components, modules, and sub-assemblies, and for menu driven instructions.

4. Increased ability to identify faults with self-diagnostics and self-clearing capability.

5. Strict control of access by the use of keys, codes, and Personal Identification Numbers (PINs).

6. Retaining critical revenue information in memory as backup for later processing if necessary.

7. Statistical, treasury, maintenance, alarm and operating data shall be collected at the equipment and transmitted to DAS in real time and stored for later retrieval through DAS polling.

8. Capability to automatically receive downloaded commands and parameters from the EME such as software/firmware changes, fare table changes, gate direction changes, configuration changes and operating parameters, synchronization of clocks, employee PIN codes, and performance control.

9. Capability to report current operational status upon receiving command from EME such as software, firmware, configuration table names and version numbers.

10. Ticket vendors and addfare machines shall have the capability to issue change.

11. TVM, AFM, and gates shall process Clipper® regional fare media.

12. Tickets or smart cards dispensed from media hoppers holding die-cut magnetic stripe tickets or Clipper® cards.

13. The TVM shall have the capability to dispense from a minimum of two ticket stocks, and have the capability to encode BART tickets using the Universal Ticket Format. TVMs modified to dispense Clipper® cards shall have the capability to dispense from a minimum of two card stocks, supporting the dispensing of extended-use Clipper® cards, limited-use Clipper® cards, or a combination of both.

14. Ticket vendors and add fare machines shall have the capability of loading value on Clipper® cards.

15. Coin recycling (re-circulation) in both the TVM and AFM.

16. All fare gate aisles shall be reversible.

17. Use of discounted fare media, including Red, Green and Orange magnetic tickets and Clipper® youth, senior, disabled cards, as well as other eligibility-based across-the-board discount fare products, at fare gates shall trigger the directional end lamps to blink to provide visual indication for the use of a discounted fare media.

18. The fare gate shall support the ability to provide audible indication for Clipper® card processing results, including successful, error and low balance conditions to assist visually impaired customers.

19. Conformance with the American with Disabilities Act (ADA) of 1990 and implementing regulations, the Americans with Disabilities Act Accessibility Guidelines (ADAAG), and the State of California Code of Regulations, Title 24.

20. Ability to issue a printed receipt that documents credit or debit transactions in accordance with Payment Card Industry (PCI) or other banking and financial services industry requirements.

21. Ability to process and encrypt Personal Identification Number (PIN) for payment card transactions using Triple Data - Encryption Standard (3DES) or a better algorithm that is PCI compliant.

22. Ability to issue a printed receipt that documents the bill and/or coin container and contents removed from a machine during treasury servicing.

23. Ability to issue printed diagnostics of machine parameters and performance.

B. Power and Voltage Requirements: AFC equipment shall operate from a single-phase power source of 277 VAC plus or minus 10 percent, 3-wire, 60Hz plus or minus 1.0 percent and 1000 volt amperes per unit maximum. Primary power shall be available at the base of the equipment. Any conditioning of the primary power or the addition of line interface filters or power supplies shall be the responsibility of the Supplier, and if required, shall be located within the equipment enclosures. The power consumption of each type of equipment shall be provided at the Conceptual Design Review. Two 115V, 15 amp Ground Fault Interrupt (GFI) convenience outlets and power breaker switches shall be provided inside each unit of equipment.

C. Physical Characteristics: The physical characteristics of the new AFC equipment shall be such that equipment can be installed in locations of current AFC equipment on existing bases without vault or floor modifications. Fill-in panels made of like material, strength, and finish shall be provided for new ticket vendors that are physically smaller than the existing equipment. The panels shall be attached to the vendor and designed to fit flush with the station wall and overlap the top and sides of the vault as indicated. Equipment dimensions and clearance requirements shall be as indicated. Supplier shall verify by field measurements actual placement characteristics, prior to Conceptual Design Review.

D. Security Provisions: The equipment shall be designed with features that deter revenue losses from the following:

1. Acts such as altering, copying, or counterfeiting the magnetic stripe tickets;

2. Theft of money or tickets with value from inside the equipment;

3. Theft of money from outside the unit of equipment extending from manipulations, tricks, and counterfeiting and copying of bills and coins to physically breaching into the equipment;

4. Theft from unauthorized changes to the software;

5. Theft from breaking the multi-pin locking concept or circumventing security access controls and PINS;

6. Theft from manipulation of printed circuit boards; and

7. Theft from falsification of records. Provisions shall be made to allow entry at the internal keypad of pre-printed ticket serial numbers to track the ticket supply in order to identify any variances between the tickets dispensed and the tickets used in resupplying the TVMs and the exit gates.

E. Stand-Alone Operation: Individual units of AFC equipment shall be capable of operating in a stand-alone mode. Any breakdown in cabling or communication links between units of equipment or computer installations in stations or at the Central office shall not affect or be noticed by customers using the equipment. The exception shall be credit and debit card transactions that shall be inoperable whenever communications to the bank are lost. In case of a communication system outage, data that is normally transmitted to DAS shall be stored by the individual units of equipment until they are ready for later automatic transmission when the interruption in communication is corrected. Faregate equipment shall not go out of service due to a full memory condition. Parameters, normally downloaded from EME shall be loadable locally, directly at the unit using the specified PC Notebook. Upon entry of the proper password, it shall be possible to upload from the unit of AFC equipment to the PC Notebook all of the locally stored information pertaining to access to the machine, maintenance and service event, financial data (money and credit/debit) and individual customer transaction.

F. Modular Design: Modules, subsystems, assemblies, subassemblies and components shall be of modular design for ease of maintenance and interchangeability, and shall conform to the following requirements.

1. Interchangeability: Modules performing identical functions shall be interchangeable. Electrical and mechanical components shall be packaged together in shop repairable and field exchangeable modules according to the function they perform.

2. Maintainability: Components shall be packaged in replaceable and repairable modules. Standard hardware and components shall be used for flexibility and ease of maintenance. Special customized carrying cases shall be provided to avoid damage to sensitive modules, as necessary, in quantities sufficient to support the level of maintenance required. Standardized commercially available hardware and components shall be used to achieve flexibility in use and to facilitate maintenance. There shall be sufficient latitude in the operating tolerances to permit the removal and replacement of modules without the necessity of making any electrical or mechanical adjustments. The use of standardized commercially available hardware and components shall not relieve the Supplier of the requirement to furnish spares for and to provide training in, the operation, maintenance, documentation, and repair of such hardware and components.

3. Weight Limitation: Modules requiring removal for off-site maintenance shall be limited to 50 pounds. Modules weighing more than 20 pounds and requiring on-site maintenance within the equipment structure shall be provided with hinges or roll-out slides.

4. Categorizing: Because different fare collection equipment require a different mix of modules, the modules shall be categorized as part of an assembly consisting of one module or a number of modules working together to perform a single function. The modules shall be identified as follows:

    a. Central Microprocessor Module;

    b. Coin System Module;

    c. Credit/Debit Card Module;

    d. Power Supply Module;

    e. Ticket Transport Module;

    f. Bill Handling System Module;

    g. Security Module;

    h. Customer Interface Module; and

    i. Smart Card Module.

5. Money Containers: Money containers shall be self-locking upon removal from equipment. Each container shall have a unique electronic ID that shall be automatically recognized when the money container is inserted into the equipment. Containers shall be ergonomically designed with no sharp edges, narrow handles or corners. Containers shall also be bar coded. Currency and coin shall be easily filled and emptied with minimum handling.

G. Maintainability: AFC equipment shall be designed to allow maintenance by BART staff. Preventive maintenance shall be allowed to be performed in the field to enable identification and isolation of a failed replaceable unit. The failed unit will be replaced to correct the failure and the unit will be sent to a BART maintenance facility for further failure analysis to determine the specific cause of failure and appropriate action.

1. Field Maintenance:

   a. The design and fabrication of the equipment shall be such that routine preventive maintenance, diagnostic troubleshooting, minor repairs, and removal and replacement of modules and assemblies can be accomplished in the field. Repairs of modules will be the responsibility of the District's secondary maintenance personnel. Software diagnostic routines shall be the primary method of isolating failures down to the module level. This shall include self-diagnostics with display of failure codes. Unsoldering shall not be required to remove replaceable modules or consumable items. Disconnection of wires from a replaceable unit shall be accomplished by the use of connectors.

   b. The primary objective shall be to reduce equipment downtime by readily removing and replacing the malfunctioning module(s) in the field. In the event replacement cannot be performed immediately and the equipment is able to remain in service, the equipment shall revert to a "degraded" operating mode. In this mode, any openings in the front panel that access the malfunctioning module(s) shall be covered or blocked to permit continued use of the equipment without increasing its susceptibility to damage.

2. Troubleshooting Aids: The primary troubleshooting aid for field diagnosis shall be the use of the failure codes. Possible failures shall be uniquely coded so that the failure can be isolated to the faulty module or subassembly. The Supplier shall demonstrate this capability on each type of equipment in a demonstration test. The Engineer and Supplier will introduce failures at random for this demonstration. Upon request from a technician using the service keyboard, the failure codes shall be displayed on either a flat panel screen or an LCD or LED display. Each displayed failure code shall be accompanied by a brief text description of the failure. A PC Notebook as shall enable cycling of the equipment around a particular set of software instructions to isolate a problem. Failure codes shall be transmitted to DAS with a date and time stamp. The number of failure codes to be provided shall be related to the complexity of the unit of equipment mapped to the failure codes reported by the individual unit of equipment. The ticket vendor, for example, shall have at least 100 failure codes that constitute a level of reference for the other AFC equipment. The most recent equipment events shall be stored in local non-volatile memory and shall be retrievable through the PC Notebook and the service keyboard. The failure codes

shall be retrievable after a power loss or CPU reset, and shall be comprehensive and detailed and shall include, but not be limited to, such failures as:

a. Decoding error;

b. Ticket jam;

c. Sequence error in handler;

d. No response from subassembly;

e. Check sum error;

f. Full memory;

g. Wrong parameter;

h. Inconsistent header;

i. Record read impossible;

j. Accounting error;

k. Cashbox/coin box removed illegally;

l. Transmission error;

m. Disk error;

n. Not initialized; and

o. File error.

3. Self-Diagnostics and Self-Clearing: Self-diagnostics shall be employed to the maximum extent possible to assure the highest possible availability. Standard diagnostic programs shall be provided for computer hardware and software programs. Customized diagnostics shall be employed to assure such items as all modules in place, communications link up, non-computer electronics working properly, battery backup ready, and monitoring of wear for signs of deterioration. The Supplier shall indicate in the Operations and Maintenance Manuals how the tests are initiated and provide a complete definition of the results of the tests and ranges of the possible results. A problem detected by self-diagnostics and problems occurring during a transaction shall be subjected to automatic resolution before the offending subsystem or the unit of equipment is removed from service. Automatic resolution shall be peculiar to each subsystem, module, or component and shall be employed in such situations as:

   a. TVM ticket invalid on first attempt and sent to the reject bin. Resolution shall be to try two more times to dispense a ticket.

   b. Coin jam in hopper. Resolution shall be to attempt to clear by reversing the motor several times.

   c. Bill jam in validator, escrow or stacker. Resolution shall be to attempt to clear by reversing motors where possible for less than a second several times and continue trying to move the bill in one direction or the other.

d. Communication session failures. Resolution shall be to automatically restart the session with the host.

e. Computer reinitialization occurs too frequently and requires excessive time to perform. Resolve by reducing the requirements to reinitialize and accomplish reinitialization, when it becomes necessary, in less than ten seconds.

f. Ticket jam in Ticket Transport. Resolution shall be to attempt to clear jam by reversing motors where possible for less than a second several times and continue trying to move the ticket in one direction or the other.

4. Fingertip Maintenance: AFC equipment shall be designed to facilitate fingertip maintenance of jammed bills, coins, tickets, and cards. Areas that are susceptible to jams such as the Bill Validator/Escrow, Coin Acceptor/Escrow and ticket handling mechanism shall be easily accessible by the station agent for the purpose of clearing the jammed media.

5. Shop Maintenance: The design and fabrication of equipment modules shall be such that detailed failure analysis of failed modules and repair of such modules can be accomplished by BART maintenance personnel. The Primary Maintenance Test Bench (see Article 7.5) is intended to identify faulty modules and submodules and to check their proper operation after repair at the Secondary Maintenance Test Bench. The Secondary Maintenance Test Bench (see Article 7.6) is intended to be used to isolate module failures to a specific failed component or components on a module or submodule. The equipment and modules shall be designed and fabricated to be completely maintained and repaired at the component level. Shop maintenance to the component level is defined as analyzing and replacing the defective circuit parts to the lowest possible level of an assembly. An example of this would be: in the case of a printed circuit board assembly, removing and replacing integrated circuits, transistors or resistors. The Secondary Maintenance Test Bench shall assist the technician in diagnosing failures within the printed circuit board assembly.

H. Computer Clock: A quartz clock shall be furnished in each unit of equipment to provide clock and calendar information through at least Year 2038. The clock shall have battery back-up in case of power loss. It shall be possible to synchronize or set the clock remotely from DAS or locally using the AFC equipment's internal service keyboard. The fare collection equipment shall also synchronize its clock to a local Network Time Protocol time source. The clock shall automatically account for leap year, days of the month, and daylight saving time. The accuracy of the clock shall be plus or minus two seconds per month.

I. Locks and Keys

1. General: Lock and key configurations for doors and internal components shall retain the present concept of designating a separate key for each of the three categories of Operations and Maintenance, Treasury, and Revenue as described herein.

2. Door Key and Lock Cylinder. The lock cylinder shall be case hardened, steel, maximum security types as manufactured by Abloy, or equal. The lock cylinder combination shall be easily changed on the cylinders already installed. At least

150 different combinations shall be possible. The key combination shall be exclusive to the District. The key and lock cylinder manufacturer shall have provisions to register and control the key combination and its distribution around the world. The key shall not be able to be duplicated on equipment normally found in local keysmith facilities. The keys shall be registered by means of confidential signature cards. The manufacturer shall not supply or sell key blanks for duplication or any other purpose. The keys shall be shipped separately from the cylinders and by registered mail. Construction cylinders shall be used by the Supplier until final acceptance or revenue service, whichever occurs first. The design and construction of the key shall be strong, rugged, unique, and virtually immune to breaking or deforming under the vigor of every day use. The cylinder drum shall be self cleaning. As an alternative to the construction cylinder, a coded staple, that is irreversible when extracted from the cylinder, and a special key can be used. Cylinder locks and their mounting attachments shall be constructed to comply with UL 437.

3. Lock Removal Procedure. The Supplier shall provide a procedure for the removal and replacement of locks which become inoperable due to such conditions as malfunction, key jams, lock openings filled with foreign materials, and damage caused by vandals or persons attempting forced entry. The procedure may include minor alterations to doors, but this should not weaken the security. This procedure shall be considered “Confidential” and delivered exclusively to the District.

4. Key Configuration for TVM and AFM

    a. The door key (operation and maintenance) shall open the front door and allow access to the panel that displays maintenance menus, and failure codes. Removal or opening of containers holding money shall not be possible with this key. The front door key shall be different at each station, and 14 keys shall be provided for each station. Removal of equipment without a valid security code shall result in a separate alarm being transmitted to DAS. Keys shall not be able to be duplicated on equipment normally available at local keysmith facilities.

    b. The Treasury Key shall allow the removal and insertion, but not opening, of the money handling containers, including but not limited to banknote box, coin box, coin hoppers, and coin recycling unit (if used). Keys shall not be able to be duplicated on equipment normally available at local keysmith facilities.

    c. The Revenue Key shall open any locked containers holding money such as the banknote box, coin box, and coin hopper which are intended to be emptied and counted or refilled at the Revenue Processing building. Key cylinders controlling access to the money shall be keyed alike and a total of 80 revenue keys shall be supplied. Keys shall not be able to be duplicated on equipment normally available at local keysmith facilities. The revenue keys shall be shipped separately from the containers via registered mail.

5. Key Configuration for Fare Gates. Gate console doors shall be lockable and the fare gate key shall open all doors on any gate console. There shall be no intrusion alarms associated with the gate consoles. A keypad and an LCD/LED

display or equivalent shall be used to gain access to the equipment and to indicate the failure codes and register readings.

6. Access Lock. The access lock in the equipment shall consist of a T-handle embedded in a case hardened steel frame. At the center of the T-handle shall be the cylinder. The top of the T-handle shall be covered by an armored plate for additional protection. The multi-point locking system on the TVM and AFM or the simpler locking system on the gates that are affixed to the backside of the door shall be fully closed or fully opened by no greater than a 180 degree turn of the pop-out T-handle. A crank may be provided in addition to a key operated cylinder to open the door.

J. ADA Compliance: AFC equipment shall comply with the requirements of the Americans with Disabilities Act (ADA) of 1990 and implementing regulations, the American with Disabilities Act Accessibility Guidelines (ADAAG), and the State of California Code of Regulations (Title 24). Instructions and information for use shall be made accessible to and independently usable by persons with vision impairments by the use of Braille and audible announcements that replicate and expand as necessary messages displayed on screens.

K. Grounding

1. General: A copper or copper-alloy, corrosion resistant, high-conductivity grounding pad shall be provided within each AFC equipment to ground conductive materials such as frames and metallic covers, motor frames, trays, and doors in accordance with NFPA 70, National Electric Code. Also refer to Section 26 05 26, Grounding and Bonding.

2. Electrical Equipment, Raceways, and Armor Cable: Exposed, non-current carrying parts of electrical equipment, raceway systems, and metallic cable armor shall be grounded by means of copper conductors. Grounding connections to the equipment shall be made with bolted connectors after the contact surfaces have been cleaned. Nonmetallic raceways shall have green color insulated grounding wire. Ground wires shall not be smaller than the circuit wires, and the ground resistance from any metallic part to ground shall not be greater than 500 milliohms.

3. Electronic Circuits: Electronic circuits and electrical assemblies shall be grounded through a network of insulated wires and/or printed circuit traces and be grounded at only one point in the cabinet. Leakage current between the equipment common grounding point and the earth with the equipment powered shall comply with Federal, State and local safety codes, regulations and standards.

4. Certification: The Supplier shall provide certification that its design and installation comply with Federal, State and local safety codes, regulations and standards that are applicable at the time of certification.

L. Displays: For internal, maintenance and servicing use, such displays as flat panel, medium intensity alpha-numeric LCD, LED readouts, or equal are acceptable. For customer use, displays shall be limited to high brilliance LED, “Active Matrix” LCD, or equal, all of which shall be readable in direct bright sunlight.

M. Cabinet Construction

1. General. Cabinets, having surfaces that are exposed to the public, including gate console surfaces, addfare machine surfaces, and the front door of the ticket vendors shall be clad in stainless steel. Stainless steel sheets shall be in accordance with ASTM A240/A240M, Type A304L and finished in accordance with ASTM A480/A480M, #4 finish, 120 to 150 grit. The direction of the grain shall be parallel to the long dimension of the surface. Special attention shall be given to the forming of the individual parts, with undesirable protruding edges and welds removed, and sharp edges and corners eliminated by a radius or chamfer. The cabinets shall be free of imperfections that affect appearance, function, or serviceability. Also refer to Section 26 05 70, Electrical Cabinets and Enclosures.

2. TVM and AFM Cabinets. The TVM and AFM shall have maximum dimensions as indicated. For vault - mounted equipment, the cabinet door or filler panels shall overlap each of the two sides and top of the vault by two inches. Internal, structural support members that provide rigidity to the cabinet and support for the door and assembly mounting brackets shall be either 300 series stainless or carbon steel, 14 gauge (.078 inch). Unpainted steel, including welds and welding material, screws, bolts and any other mounting hardware shall be stainless steel or carbon steel treated to prevent corrosion and rust by the use of special treatment such as galvanizing, zinc or cadmium plating. The mounting hardware shall conform to ANSI or ISO standards for mechanical fasteners.

    a. Fastenings: Fastenings shall be concealed wherever possible. There shall be no exposed bolt heads or nuts.

    b. Exterior Surfaces: There shall be no sharp corners, non-functional or unnecessary cracks or openings on the outside surfaces. Exposed corners shall be rounded or metered, welded, and ground smooth. Stainless steel shall be formed around corners so that edges are folded and concealed from customers view when doors are closed. Displays, buttons, bezels, trims and labels shall be aligned parallel to their mounting plate. Weld marks burrs, discolorations or distortions resulting from either fabrication or shipment shall be removed.

    c. Panels: The cabinet shall be fabricated with panels and re-enforcing members, all welded together to form a rigid and structurally sound unit. The sides, back and top of the TVM cabinet shall be 18 gauge (0.05 inch) minimum, stainless or carbon steel sheets in accordance with ASTM A1008/A1008M. Gaps between panels shall be uniform with not greater than one-eighth inch separation.

    d. Design Loads: Ticket vendor and addfare machine cabinets shall be able to sustain a concentrated load of 200 pounds applied to any area of 1.4 square inches through a resilient pad, or a uniformly distributed load over an entire

surface of 50 pounds per square foot without causing damage or permanent deformation. The uniformly distributed load shall not deflect the cabinet surface more than 0.02 inches at any point.

e. TVM and AFM Door:

1) Doors shall be constructed of at least .060 inch thick stainless steel lined with at least .080 inch thick carbon steel. Alternate design employing 14 gauge (0.078 inch) stainless steel reinforced by 14 gauge (0.078 inch) stainless steel structural members to provide rigidity will be acceptable.

2) Doors shall be equipped with multi-point locking concept, employing rotating clamps or sliding vertical and horizontal bars or equivalent operated by the T-handle or key lock. A minimum of one locking point on the top, one on the bottom and two on the unhinged side, or equal, shall be used. A minimum of three case hardened steel hinges shall be used which are, or their hinge pins are, entirely within the cabinet. The hinges shall be located on the right side of the door and shall allow the door to open and lock in place at approximately the 90 to 105 degree position. The door shall open and close smoothly with no greater than ten pounds force applied. The position locking mechanism shall be a simple drop bar or equal, easily released, and installed at a location, preferably near the top, where it does not interfere with access to the modules and sub-assemblies.

3) A compressible seal or equal shall be used around the perimeter of the door to prevent the entrance of dust and liquids. The door for the TVM shall overlay the cabinet and the surrounding wall, as indicated. The door for the AFM shall not exceed the maximum width and height dimensions of the cabinet. Both TVM and AFM doors shall be designed such that devices like pry bars are ineffective in forcing the door open. At the 90 degree open position, both doors shall be capable of sustaining a force in a plane through the hinges of 300 pounds applied to the top corner, away from the hinge, without incurring any damage including buckling, breaking of displays, permanent deformation, and misalignment.

f. Base Leveling Plate and Elevation Adapter

1) Each vault-mounted TVM/AFM shall be provided with a base leveling plate that shall be bolted to a steel re-enforced concrete pedestal and to the TVM/AFM. It shall be possible to mount the furnished TVM/AFM directly or by means of a base elevation adapter to the base plates. Adjustments for leveling shall be provided. The Supplier may re-use the existing base plates where existing TVM/AFM are being replaced. The Supplier shall provide base plates as necessary at new TVM/AFM locations and at locations where existing base plates are missing or are damaged. The base plate shall be of same non-corrosive material and size as those of existing base plates, and designed to allow TVM/AFM to slide on during installation and removal. Built in rack out mechanism is optional.

2) A free-standing TVM/AFM shall be provided with a base elevation adapter that shall be bolted directly to the finish floor. The base elevation adapter shall not exceed the maximum width and depth dimensions of the TVM/AFM nor shall they be less than two inches of each dimension. Construction shall be equivalent to the TVM/AFM requirements.

3) Sufficient maintenance access to the power and signal cabling serving the TVM, and AFM, shall be provided. This shall be accomplished with an open-bottom cabinet design, or a base elevation adapter as indicated.

g. Telescopic Slides: Modules and components that are part of a particular assembly and are located within the TVM and AFM shall be mounted on telescopic slide. Telescopic slides shall be designed to accommodate not less than 200 percent capacity of the weight of the modules and components mounted thereon. The telescopic slide sections shall roll on ball bearings. At its fully extended position, the slide shall not waver horizontally more than one inch or be easily deformed by minor bumping that could be expected during servicing. The slide shall contain detents in the non-extended and fully extended positions to hold the slide in place. A simple pulling or pushing action shall move the slide from its detent position. A shock-absorbing device shall be installed at the rear detent to reduce the shock level, thereby preventing damage to the sub-assembly when it is pushed-in to its “home” position. Slides shall be designed for no less than 500,000 operations.

h. Cabinet Light: Readily accessible fluorescent lighting shall be installed inside the TVM and AFM cabinets to provide sufficient light for the functions to be performed by servicing and maintenance personnel. The opening and closing of the door shall automatically control the power to the lighting arrangement.

3. Gate Console. The external design, material and dimensions of gate consoles shall be identical to the existing gate consoles, including slope ends, and locations of ticket insertion and return slots as indicated. The base plates and installation except for the cabling shall also be identical. Drawings and other details that are available will be provided to the Supplier upon request. The following requirements shall be met:

a. Outside dimensions as indicated.

b. Welded, reinforced panels of stainless steel, 12 gauge (0.109 inch) minimum on all surfaces including the access doors. Gaps between panels shall be uniform with not greater than one-eighth inch separation.

c. Hinged and removable doors on both sides.

d. The top cover shall open laterally from a side hinge. The cover shall be hinged such that there is no interference with the adjacent aisle in its open position. Top cover shall be held in the open position with a gas strut or equivalent mechanism.

e. Easily changeable barrier locations to suit the installation.

f. Internal metal parts, fasteners, brackets, braces, and channels to be stainless steel.

g. The Supplier shall use existing base plates as available where new gates replace existing gates. The Supplier shall provide additional base plates at new locations and at locations where existing base plates are damaged or missing. The new base plate shall be interchangeable with the existing base plate. New gate consoles shall be able to be installed in place of existing gate consoles without replacing the base plates. The base plates shall be constructed of stainless steel or C1018 carbon steel with 0.0003 inch zinc plating or equivalent.

h. If ventilation is required, the vents shall be located in the longitudinal center of the gate console sides, as indicated.

N. Electronics: Electronics circuits in AFC equipment shall be mounted on printed circuit boards (PCB) for ease of handling and repair. Electronic circuits shall include digital logic, drive circuits, power supply circuits, relays, solenoids, batteries, RAMS, PROMS, EPROMS, communication interfaces, input/output ports, CPU's, drives for floppy disks, hard disks, keyboards, terminal printers, line printers, and discrete electronic components. Computer equipment including the CPU and peripherals shall be commercially available within the USA and shall be IBM PC compatible. Microprocessors shall be of equivalent quality of IBM PC compatibles and the processor performance shall be of the highest processor performance available as of the final design review. For customized electronics, CMOS circuitry shall be used to the extent possible. The design shall be centered around a microprocessor system consisting of a central processing unit, equivalent to Intel AMD or Cyrix products, various types of memory storage, and access interfaces necessary for access to the software programs, stored information and for communication between other units. Drive circuits such as output ports used to drive lamps and relays, shall employ protective devices as necessary to prevent damage to either the drive circuit or to the load when subjected to continued use such as can be experienced during the cycling tests. Such protective devices shall be easily replaceable without soldering. This protection shall apply to test as well as normal conditions.

O. Printed Circuit Boards (PCBs)

1. General. Customized PCBs shall have copper traces and gold-plated connections and be fungus resistant. PCBs shall be designed for normal handling in the shop without incurring damage. Keying shall be employed such that the PCB cannot be plugged into the wrong connector nor make any type of electrical contact with the wrong connector upon attempting to insert. PCBs shall be shielded against electrical short circuits and be protected against contact with foreign objects.

2. Test Terminals. Test terminals or connectors shall be provided as necessary in easily accessible and non-critical areas of the PCB for maintenance use.

3. Component Identification. Identification of each discrete component shall match the schematic diagram and shall be placed on the PCB as close to the component as possible. Each PCB shall also be identified by a unique, permanent serial number. In addition, a bar code shall be attached that is identical to the printed serial number.

4. Construction. PCBs shall be constructed with epoxy glass reinforcement with plated through holes and shall meet the following standards: NEMA Grade FR-4 (peel strength load limit of 5), IPC 2221A and IPC 2221B relating to the copper traces. Circuit sides shall be shielded against electrical short circuits and contact with metal objects.

5. Connections. Components such as EPROMS and others that are intended for frequent replacement, primarily to change the memory contents, shall not be soldered in place and shall be easy to extract and replace without incurring damage to the pins or degrading the electrical contact. Additionally, microprocessor, micro-controller or programmable array logic devices shall be socketed.

6. Artwork. Artwork for Supplier-developed PCBs shall be furnished. Excluded from this requirement are commercially available standard OEM-supplied PCB's. The artwork shall be furnished in both camera-ready and electronic formats (Gerber files).

P. Relays: Relays provided shall be electronic solid state relays, sized appropriately, and shall not be ganged-operated in order to share the load. Plug-in relays shall be secured by mechanical fasteners if installed on vertical panels or if employed in equipment subject to vibration. Relays shall be optically isolated from the AFC equipment microprocessor assembly.

Q. Cables, Wires and Connectors

1. Wire and Cable Conductors. Wire and cable conductors shall be American Wire Gauge (AWG) sizes based on copper conductors. Conductors shall be sized on the basis of equipment loads and operating parameters in accordance with the NFPA 70, National Electric Code (NEC) and as indicated. Power wiring shall be copper or copper alloy with 600 volt, moisture and heat resistant, thermo-plastic insulation rated for 170 degrees Fahrenheit. Minimum size shall be No. 14 AWG. Signal and control wiring shall be minimum No. 18 AWG, NFPA 70, NEC type THW moisture and heat resistant thermoplastic insulation, or equal rate for 170 degrees Fahrenheit. Cables and wiring shall not support combustion or emit toxic chemical compounds when burned.

2. Raceways. Raceways shall be in accordance with the NFPA 70. Color coding of conductors shall conform to NEMA WC-71 and NEMA WC-74.

3. Connectors. Power and control wires shall be terminated with multi-pin plug connectors or on terminal blocks having washer-head screw terminals or the equivalent to accept "positive" type wire lugs such as the closed ring design. A minimum of 30 percent, but not less than two, spare terminals shall be provided on each terminal block. Connections between each unit of equipment and the cables in the wireways shall be made through connectors located internally at the bottom of each piece of equipment. Connectors shall be factory installed to the extent possible. Connections to or from the equipment shall be made by connectors and not hardwired to terminal boards. Connectors shall be keyed, have quick disconnect fasteners, and be equivalent in quality to industrial grade connectors as manufactured by Amphenol, Winchester, 3M or equal. The

mechanical strength of each connection shall be at least 85 percent of the mechanical strength of the wire. The electrical conductivity of each connection shall be at least 95 percent of the electrical conductivity of the conductor. Connectors that are intended to be removed and/or disconnected for Treasury servicing shall be durable and suitable for the service intended. The connectors shall be designed for no less than 5,000 operations, and shall be easily replaced with no cutting or resoldering of existing wires or repinning of connectors.

4. Identification. Conductors within a cable, separate wires, and cables shall each be identified by machine printed, permanent plastic identification sleeve, tag, label or equivalent. Cable tags shall identify the source and destination of the cable. Tags shall agree with the identification numbers that appear on the wire lists, schematic diagrams, and cable schedules.

5. Cable Installation. Cables inside equipment shall be supported near terminal points and all along its route to minimize accidental interference and contact. Sufficient length shall be provided to permit removal of modules and withdrawal of sub-assemblies mounted on telescope slides and installed such that cables and ribbon connectors shall fold naturally requiring no special action when, for example, a telescopic slide is returned to its “home” position. For units that telescope in and out, cable dressing shall be provided to prevent damage by handing of the cables and prevent stress on the connectors.

6. Testing. After installation, cables shall be tested to assure that the electrical and mechanical properties of the cables have not been degraded. The test results that shall include a continuity check and identification of cables and wires shall be recorded and submitted for approval.

R. Safeguards: The safety of patrons and operating personnel using the equipment or performing their duties shall be an essential aspect of the fare collection equipment design and fabrication. The Supplier shall provide appropriate safeguards wherever required by safety regulations and logical considerations. Such safeguards shall include shields or barriers placed to prevent injury, including burns from heated surfaces, or cuts from sharp edges.

1. Electrical Safeguards. Provisions shall be made to prevent electrical shock from harmful levels of voltages. Interlocks shall be provided which disconnect voltages exceeding 150 volts. An interlock bypass shall be provided for servicing, accompanied by an indicator showing the state of the bypass. Guards, safety covers, and warning plates or labels shall be provided for servicing, accompanied by an indicator showing the state of the bypass. Guards, safety covers, and warning plates or labels shall be provided for devices with contacts, terminals, and similar parts having a potential exceeding 300 volts. Each unit of fare collection equipment shall have an easily accessible circuit breaker within the equipment to open the supply circuit. In the off position, the only power to the machine shall be at the 115 volts, 15A convenience GFI outlets to be provided which shall also be controlled by a circuit breaker.

2. Mechanical Safeguards. Metal or plastic guard plates shall be provided to protect personnel from fan blades, motor shafts, belts, solenoids and other moving parts. Areas of high temperature shall also be protected against injury. Areas that can

come in contact with patrons, especially the side and top areas of the gate consoles, shall be given added attention to assure that any kind of injury or snagging of clothing is highly improbable. The fare gate barrier leaves and aisle sensor control shall be designed to prevent making contact with customers or their belongings in the fare gate aisleway.

S. Painting and Plating

1. Exterior Surfaces. Exterior non-stainless steel surfaces shall be painted using a four-coat system or equivalent. Internal areas, that are painted, can use a two-coat system. Metal surfaces shall be prepared in accordance with the paint manufacturer's instructions. The first coat shall be one coat of an inorganic zinc primer between two and four mils thick, followed by three coats of epoxy enamel or equivalent. The final coat shall have a matte or satin finish. Parts or areas in contact with concrete or masonry walls or floors shall receive a minimum of two coats of rust and corrosion preventive primer and two coats of non-corrosive finish paint.

2. Interior Surfaces. Interior unpainted metal surfaces shall be zinc or cadmium plated or equal applied in accordance with their appropriate standards, such as SAE AMS-QQ-P-416 for cadmium plating.

T. Acrylic: If acrylic is employed, it shall be Rohm and Haas brand high impact, plexiglass #70 or equal. The acrylic material shall meet the requirements of NFPA 101, class A.

U. Polycarbonate: If polycarbonate sheets are used for protection of screens, displays, graphics, or surfaces, they shall be mar-resistant, type Lexan MR-5000 as manufactured by General Electric Corp. or equal. The polycarbonate shall meet the requirements of NFPA 101, class A.

V. Sealants: Sealants for use between the base plates or cabinets and the floor shall be a black color, DOW Corning #780 building sealant, polyurethane-based, either one-part elastomeric sealant, complying ASTM C920, Class A, Type I, or two part elastomeric sealant, complying with ASTM C920, Type I or equal. Sealants shall meet the requirements of NFPA 101, Class A.

W. Customer Interface Graphics: Customer interface graphics for the TVM and AFM front panel shall be engraved on stainless steel plates affixed at appropriate locations on the front panel. The graphics shall be engraved into the stainless steel using etched graphics. Graphics shall include pictorial and printed information as indicated.

X. Fare Tables: The faregate and AFM shall be provided with memory space for peak and off-peak fare tables for each supported fare product. Each faretable shall be configured as a 64 by 64 matrix to accommodate the existing stations and future expansions. Information regarding fare structures will be furnished by the District.

1. Default Fares: One faretable shall be programmed with the default fares. This faretable shall be used to determine the fares for all ticket types and shall be in effect at all times unless preempted by other special fare products, special fare periods or faretable settings.

2. Fare product based fares: fare gates and AFMs, if configured, shall use alternate fare tables for special fare products, such as Clipper® discount products, airline/airport employee discount programs, etc.

3. Off-Peak Fares: If configured, the faregates and AFMs shall use an alternate off-peak fare table for each supported fare product during the off-peak periods (e.g. 10 AM - 3 PM).

4. Reserve Faretables: The memory space and software programs for the remaining faretables shall be reserved for future use.

5. Faretable Implementation: For a faretable change, it shall be possible to download the new faretable from the EME ahead of the implementation date. The only requirement to activate the new faretable shall be a system-wide execution command from EME, a local execution command from the maintenance terminal, or an automatic control signal initiated by the faregate/AFM clock. All three options shall be provided.

2.04 SOFTWARE

A. General: Software programs shall be modular and structured using a hierarchical framework. The work shall be divided into divisions of importance where the work with the highest importance shall be assigned top priority and the next level of importance shall receive the second priority, and so on. Complete software documentation shall be provided. The information supplied shall contain sufficient annotation to enable the District to understand and interpret the software with relative ease and permit changing of any part of the software without the necessity of relying on the Supplier for software changes. System variables shall be identified and documented. Procedures on how to change these variables shall be supplied. Information to be supplied shall include source codes, disk files, programming statements or lists, subroutines, and operating flow charts applicable to all equipment supplied. The listings provided shall contain an adequate percentage of annotations to help in the understanding of the listing. Comments and annotations shall be in the English language. The information to be supplied shall also include the data stored in each of the EEPROMS or equivalent memory chips, memory maps, object files, Hex files, and source files. Files including schematics and JEDEC files to create PALs, GALs, and FPGAs if used shall also be supplied. The information shall be supplied on Microsoft Windows® compatible CDROMs, DVDs or USB storage. Hardware and software development tools required for reconfiguring, modifying and deploying the software shall be provided. The above documentation shall be provided as part of a Software Manual. Engineering training for the modification and deployment of modified software shall be provided.

B. Configuration Management: Changes to AFC Equipment variables such as operational parameters, faretables and display messages shall be made via the Engineering Maintenance Equipment (EME) platform. The EME shall be able to download configuration changes to the AFC equipment as described below, and query the AFC equipment for current operating parameters via the network. The changes to variables shall be easily implemented in the equipment without the necessity to modify the application software or to retest the changes

C. Downloading. Downloading of commands and parameters shall be accomplished remotely from EME, and locally using the PC Notebook. Downloading locally with the PC Notebook shall be accomplished using standard communications protocols, cables and connectors. Necessary cables and connectors shall be provided. The downloaded information shall include specified commands and parameters.

D. Software Use and Verification. Software shall be complete and fully tested prior to shipment of the respective equipment. The software shall be fully programmed, debugged and updated with the latest changes prior to the predelivery tests. The Supplier shall incorporate source code modified by the District into the software, and provide the latest version of software source code and documentation for use during Supplier-conducted operation and maintenance training. The Supplier shall provide the final software source code and documentation prior to revenue service for the first equipment. Software source code, object code and documentation shall be provided on CD-ROM, DVD or USB storage in a Microsoft Windows® compatible format. Upon entry of the proper command into the service terminal, the AFC equipment shall generate a printed receipt showing the software part number and version of installed software.

E. Any software that processes, stores or transmits credit card data shall be compliant and lab tested and certified with the latest Payment Application Data Security Standards (PA-DSS) as defined in the PCI Data Security (PCI DSS) standards, or already listed on the PCI DSS website as Validated Payment Application with a valid expiration date which is at least 5 years from the date that the software is delivered.

F. The equipment operating system shall be patched with the latest updates and patches provided by the provider of the operating system. The equipment shall support antivirus, anti-malware, and file integrity monitoring software.

2.05 DATA COMMUNICATION INTERFACE

A. General. A Network interface shall be provided in each unit of equipment to enable communications with the DAS and EME. The interface shall use a TCP/IP protocol. An Ethernet Network Interface Card and 100MB/1GB fiber optic transceiver shall be installed in each unit of AFC equipment. The interface will be securely mounted inside the communication interface box provided by others at the base of each piece of equipment. The Supplier shall provide connectorized cables from the equipment to the communications interface box. The Network layer of the TCP/IP protocol stack shall conform to the latest Internet Standards. The Network Interface shall include an SNMP agent with support for MIB II and other appropriate vendor specific MIBS.

B. Data Acquisition System Interface. The microprocessor assembly in each machine shall communicate with the DAS and EME using the VEI protocol. Detailed information on the protocol will be provided to the Supplier after Contract Award and upon execution of a confidentiality agreement.

C. Hardwired Communication Interface. A hardwired communication interface shall be provided in each unit of equipment to support the control and status indication functions shown below. The Supplier shall submit a detailed description of this interface for approval during the Preliminary Design Review.

1. TVM and AFM. Relay contact closures rated at 24 VDC shall be provided to annunciate the following machine status conditions:

    a. Out-of-Service

    b. Intrusion Alarm

    c. Loss of Power

    d. Loss of DAS Communication

    e. Front Door Opened

2. Faregates. Relay contact closures rated at 24 VDC shall be provided in the faregate and AFG to support the indicated functions.

    a. Status Indications

        1) Gate Out-of-Service

        2) AFG Gate Barrier Forced Open (AFG Intrusion Alarm - activated as long as the gate is forced open).

    b. SCADA Control Functions - Relay contacts rated at 24 VDC shall be provided that respond to a momentary contact closure command from a remote device to support the control functions listed below. These relay contacts shall be reserved for future SCADA use:

        1) Barriers Open (on/off);

        2) Barriers Close (on/off);

        3) Override Clock Check (on/off);

        4) Not Override Clock Check (on/off);

        5) Override Entry/Exit Check (on/off); and

        6) Not Override Entry/Exit Check (on/off).

        Note that the status of the above conditions shall be reported by the faregate to DAS.

3. The relays shall interface via the connectors to mating connectors provided by others. For the faregate, the relay connectors shall be brought out to the end console of each array closest to the station agent’s booth.

4. The existing annunciator panel in the agent booth will be retrofitted by others to display the indicated statuses. The Supplier shall design the Hardwired Communication Interface to conform to the electrical characteristics of the panel.

5. Each unit of equipment shall be provided with three spare relays to support future control and data acquisition applications. The spare relays shall be terminated on connectors and connected to the AFC equipment logic.

6. Electronics and power needed to control and monitor the relay contacts shall be provided.

PART 3 – EXECUTION

Not Used.

END OF SECTION 34 50 10

SECTION 34 50 11

FARE COLLECTION SYSTEM INSTALLATION

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Site preparation necessary to support installation of AFC Equipment (AFCE).

B. Installation and testing of AFCE.

C. Materials for installation of AFCE, and connection of the AFCE to the BART Data Communications Network (BARTnet).

1.02 RELATED SECTIONS

A.	Section 01 32 16	Construction Progress Schedule
B.	Section 01 33 00	Submittal Requirements and Procedures
C.	Section 01 33 23	Shop Drawings, Product Data, and Samples
D.	Section 01 43 00	Quality Assurance
E.	Section 01 45 00	Quality Control
F.	Section 01 45 24	Testing Program Requirements
G.	Section 01 74 14	Cleaning
H.	Section 01 78 23	Operation and Maintenance Data
I.	Section 01 78 39	Project Record Documents
J.	Section 01 78 44	Spare Parts and Maintenance Materials
K.	Section 01 79 00	Demonstration and Training
L.	Section 20 50 13	Raceways for Facility Services
M.	Section 20 70 19	Indoor Cabinets, Racks, Frames and Enclosures
N.	Section 20 72 10	General Requirements for Systems Work
O.	Section 20 70 23	Electronic Circuits, Wires, and Cables
P.	Section 20 70 26	Common Materials and Methods for Electrical Systems
Q.	Section 20 72 15	General Requirements for System Design
R.	Section 20 72 25	Factory and Field Testing Requirements
S.	Section 20 80 00	Systems Integration Testing

T.	Section 22 15 00	General Service Compressed Air System
U.	Section 26 05 26	Grounding and Bonding for Electrical Systems
V.	Section 27 13 01	Communication Cables and Related Equipment
W.	Standard Drawings J001	AFM/TVM Elevation Criteria
X.	Standard Drawings J002	AFM/TVM Base Details
Y.	Standard Drawings J003	AFM/TVM Vault Mount Leveling Plate
Z.	Standard Drawings J004	AFM/TVM Elevation Adapters
AA.	Standard Drawings J006	Fare Gates, Base Details
BB.	Standard Drawings J007	Fare Gate, Pneumatic Lines
CC.	Standard Drawings J010	Base Plate
DD.	Standard Drawings J011	Fare Gates, Electrical
EE.	Standard Drawings J013	Parking Validation Machine – Base and Mounting Details
FF.	District Technical Manuals	SCADA System Function Description

1.03 MEASUREMENT AND PAYMENT

A. Measurement and payment for Fare Collection System Installation will be by the lump-sum method in accordance with Contract Specification Section 01 20 00, Price and Payment Procedures.

B. Fare Collection System Installation will be paid for at the Contract lump-sum price as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. American National Standard Institute (ANSI):

1. ANSI C2 National Electric Safety Code (NESC)

B. California Electrical Code

C. Code of Federal Registration (CFR):

1. 36 CFR Part 1191 Part of Federal Register, Volume 56, No. 14, the “Americans with Disabilities Act”

D. Electronics Industries Association (EIA):

1. EIA/ECA-310-E Cabinets, Racks, Panels, and Associated Equipment
2. EIA 455-11-177A Standards for Test Measurements and Inspection of Fiber Cables, Connectors, and/or Other Fiber Optic Devices

E. Americans with Disabilities Act (ADA):

1. Americans with Disabilities Act Accessibility Guidelines (ADAAG)
2. California Code of Regulations (CCR): Title 24 Building Standard Code

F. San Francisco Bay Area Metropolitan Transportation Commission (MTC):

1. Clipper® Card Specification

G. Cubic Transportation Systems, Inc. (CTS):

1. Drawings 9375-4102 Fare Gates Installation.

1.05 ABBREVIATIONS

AFC	Automatic Fare Collection
AFM	Add-Fare Machine
AFG	Accessible Fare Gate
BARTnet	BART Data Communications Network
BBC	Bill to Bill Changer
BOSC	BART Only Smart Card
DAS	Data Acquisition System
DMP	Designated Matching Products
EBO	Emergency Barrier Override
FG	Fare Gate
PVM	Parking Validation Machine
SAB	Station Agent Booth
SCADA	Supervisory Control and Data Acquisition
TVM	Ticket Vending Machine

1.06 DESCRIPTION OF THE EXISTING SYSTEM

A. BART's AFC system consists of the following Automatic Fare Collection Equipment (AFCE): TVM, AFM, FG, PVM and BBC. The AFCE operates as a stored-value, distance-based system. The system is a closed-barrier type, requiring a magnetic strip ticket or smart (Clipper® or BOSC) card for entry and exit at the station. TVMs issue and upgrade the fare media (e.g., magnetic strip tickets and Clipper® cards). AFMs upgrade magnetic strip tickets and Clipper® cards that require added value to exit the FG. BBCs make change for 10 and 20 dollar bills. An air compressor unit provides air to the FG for controlling the opening and closing of the pneumatic FG barrier.

B. The TVMs, AFMs and FGs are equipped with two communications interfaces. The primary interface connects each machine to the Data Acquisition System (DAS) servers at BART computer rooms via a fiber optic connection to the station network switch and the BARTnet data network system. The second interface connects the SCADA module in each AFC device to the station SCADA system. The SCADA connection provides a back-up communication interface to the DAS system for certain control and status indication functions of the AFC Equipment. For TVMs and AFMs, these functions include status indications such as "Out of Service", "Intrusion Alarm", and "Loss of Power". For Fare Gates, SCADA supports control functions such as "Clock Override", "Entry/Exit Override", and "Emergency Barrier Open". Additionally, there is a 2-conductor cable from the station agent booth to the Fare Gate arrays that provides back-up control of the "Emergency Barrier Open" function. PVMs and BBCs use only the fiber communication interface to the DAS.

1.07 SUBMITTALS

A. Submittals shall be in accordance with Section 01 33 00, Submittal Procedures; Section 01 33 23, Shop Drawings, Product Data and Samples; and Section 01 78 44, Spare Parts and Maintenance Materials.

B. Manufacturer's data sheets and descriptive information for Contractor furnished equipment.

C. Detail drawings and technical data including list of equipment and material, consisting of manufacturer's descriptive and technical literature, reliability performance charts and curves, catalog cuts, and installation instructions. Drawings shall show proposed layout and anchoring of equipment. System drawings shall show final configuration, including location, type and termination of inter-cabinet cables.

D. Provide station layout drawings for installation of AFC equipment and ancillary equipment. The drawings shall identify installation sites, equipment placement details, ADA compliance, raceway and conduit runs, cable runs, and equipment installation and termination details.

E. For Contractor furnished equipment, provide the following quality assurance/control submittals:

1. Quality assurance and quality control submittals shall be in accordance with Section 01 43 00, Quality Assurance; and Section 01 45 00, Quality Control.

2. Certificates: Where equipment or materials are specified to conform to the standards or publications and requirements of CFR, ANSI, NFPA, EIA, or UL, submit certificates attesting that the items furnished under this Section conform to the specified requirements.

F. Manufacturer's instruction: Where installation procedures, or any part thereof, are required to be in accordance with the recommendations of the manufacturer of the equipment being installed, submit printed copies of these recommendations for approval prior to installation. Submit operating instructions outlining the step-by-step procedures required for system operation including description of each subsystem in its operating mode. Instructions shall include the manufacturer's name, service manual, parts list, and a brief description of equipment, components, and their basic operating features. Submit maintenance instructions listing regular maintenance procedures, possible system failures, a troubleshooting guide for repairs, and simplified diagrams for the system as installed.

G. Operation and Maintenance Manuals: Updated operation and maintenance manuals for Contractor furnished equipment in accordance with Section 01 78 23, Operation and Maintenance Data.

H. Training: Training shall be provided if repair procedures change due to part replacement of an obsolete part. Submit training materials in accordance with Section 01 79 00, Demonstration and Training.

I. Spare Parts: Provide the spare parts in accordance with Section 01 78 44, Spare Parts and Maintenance Materials.

1.08 NOT USED

1.09 DESIGN REVIEWS

A. Design reviews may be necessary if significant changes are noted during the District's review of the various documents requested for submittal.

1.10 WARRANTY

A. For equipment provided by Contractor, the following provisions shall apply in place of the warranty provisions in the Contract general conditions where warranty starts after Acceptance:

GC4.9.4 Warranty of Contractor Furnished Equipment and Materials. Notwithstanding the guaranty provisions previously specified, the contractor warrants that all non DFE equipment, materials, and labor furnished or performed to install such equipment under the Contract shall be satisfactory for their intended

purposes and shall be free of defects in the design, materials, and workmanship for a period of 24 months from and after start of revenue service unless specified otherwise in these specifications, regardless of whether the same were furnished or performed by the Contractor or by any of its Subcontractors. Upon receipt of written notice from the District of any defect in any such equipment, materials, or labor during the applicable warranty period due to defective design, equipment, materials, or workmanship, the affected item or part thereof shall be redesigned, repaired, or replaced within a time period and in a manner acceptable to the District.

PART 2 – PRODUCTS

2.01 GENERAL

A. Furnish the following pieces of equipment for installation unless they are District-Furnished Equipment (DFE) in accordance with Contract. The equipment shall be certified by manufacturer.

2.02 AFC EQUIPMENT

A. Provide:

1. FGs, AFMs, TVMs, BBCs and PVMs as specified in Contract.

2. Related installation hardware such as elevation adapters, base plates, filler panels, and afterset inserts as listed in Designated Matching Products.

3. Installation accessories such as inter-gate air hoses and cables, and anchor rods.

4. Sealants shall be black color, Dow Corning #780 building sealant or equal, polyurethane-based, either one-part elastomeric sealant or two-part elastomeric sealant. Sealants shall meet the requirements of NFPA 101, Class A, and UBC Chapter 42, Class I.

2.03 SUPPORT EQUIPMENT

A. Provide

1. Air Compressor Rack as specified in Contract.

2. DeviceNet cable, fiber patch panels and patch cords for networking as specified in Contract.

3. Fiber interface box (splice cassette and a housing) as listed in DMP.

PART 3 – EXECUTION

3.01 SITE ACCESS

A. Access to the Jobsite will only be permitted per approval from the Engineer.

B. Provide pedestrian and patron control in accordance with Section 01 57 00, Temporary Controls.

3.02 SITE PREPARATION AND CLEANING

A. Refer to BART Facilities Standard Drawings J001 through J013 for FG, AFM, TVM, and PVM installation details. Air Compressor Rack installation details are as those of vault mounted TVM.

B. Refer to the Contract Drawings for station layout of AFC Equipment.

C. Floor and Ductwork:

1. Inspect locations where the AFC Equipment will be placed to ensure that placement provisions, including raceways, wireways, cabling, and anchor bolts, are satisfactory. Surveys and inspections shall be made as necessary prior to the placement of the AFC Equipment. Any discrepancies that will affect the placement or operation of the AFCE shall be reported in writing to the Engineer.

2. Trench and core drill the finished floor, and install conduits, cable ducts, cable penetrations and hardware in accordance with Section 20 50 13, Raceways for Facility Services, to permit the pass through and connection of power cables, communications cables, and pneumatic airlines (FGs only) to be installed.

3. Standing area and perimeter around AFCE shall be level to meet ADA requirements. Floor refinishing work shall be completed and accepted by the District before AFCE can be installed.

4. Clean up Jobsite in accordance with Section 01 74 14, Cleaning.

D. AFC Equipment Removal and Storage

1. For each AFCE to be relocated, unplug the power cable, disconnect the communication cables, unbolt the AFCE from the mounting hardware, and place the AFCE in a temporary storage area as designated and agreed upon by Contractor and the Engineer. Security at the storage areas shall be the responsibility of the Contractor. Contractor shall take measures to prevent unauthorized entry to the storage area.

2. After removal of the AFCE, remove the mounting hardware and store in the temporary storage. Prepare the floor area for rework by removing obstructions located in the area in which the AFCE was removed including, but not limited to, anchor bolts, raceway collars and pneumatic fittings. Obstructions shall be

removed down to 1/2 inch below grade. Floors not within any rework area and reworked floors shall be repaired and refinished.

E. For each AFCE (FG, TVM, AFM, BBC, PVM) provide the following:

1. A 277 VAC, 20 Amp dedicated circuit from the station power panel with grounding as indicated.

2. For stations where DeviceNet cables are not used, provide a 12-strand multimode fiber optic cable from the station 201 communication cabinet as indicated. Otherwise, provide a 6-strand multimode fiber optic cable. Follow installation instructions in Section 27 13 01, Communication Cables and Related Equipment. Coin and protect a 15-foot slack of the cable. The District will terminate the cable.

F. For each FG, TVM, and AFM provide:

1. SCADA communication cable in accordance with Section 27 13 01, Communication Cables and Related Equipment, from the SCADA cabinet in the train control room to each FG, TVM, and AFM as indicated. The District will terminate the cable in the FGs, after the FGs are installed.

G. For each FG provide:

1. A daisy chained 2-conductor copper communication cable from the station agent booth via Cabinet 44 in the train control room to each FG as indicated for the EBO function. The District will terminate the cable in the FGs after the FGs are installed.

2. Pneumatic air lines from the FG to adjacent FGs, or to an adjacent FG and the air compressor rack as indicated.

H. For air compressor rack installation, prepare the floor surface of the designated vault, and provide the following:

1. A 480 VAC 3-Phase 30 Amp dedicated circuit from the station power panel to the air compressor rack.

2. Pneumatic air line from the air compressor rack to the FGs.

Air compressor rack shall be installed on a metal plate and mounted on a heavy-duty bottom slide listed in DMP. The slide shall mount on a vault-mount leveling plate (see DMP) and anchored to the concrete.

3.03 INSTALLATION

A. The Engineer will oversee the installation and testing of the AFCE and the air compressor rack. Provide a qualified representative from the AFCE manufacturer to support the installation and testing of the AFCE, and a qualified representative from the air compressor rack Supplier to support the installation and testing of the air compressor rack. Make available facilities and equipment at all times to the Engineer,

and meet with and cooperate with the Engineer as needed on installation and testing issues including, but not limited to, scheduling, District AFC support, and performance assurance.

B. AFC Equipment Installation

1. If applicable, transport removed AFCE and associated mounting hardware (bases and base plates) to temporary storage, and transport AFCE and associated mounting hardware from temporary storage to the Jobsites.

2. If applicable, pick up District furnished AFCE from a District designated storage facility and deliver the Fare Gate Consoles to the Jobsite.

3. AFCE installation work shall be under the direction of the AFC equipment or air compressor representative and coordinated with the Engineer.

4. Install the AFCE bases/base plates and set the AFCE at the locations indicated. Shim plates for leveling and eliminating space between the AFCE and its base or baseplate. Apply sealants between the bases/base plates or cabinets and the floor.

5. Prior to setting the FG in place, coordinate with the Engineer on the District's installation of the inter-gate cabling. Ensure that FGs are plumb, level, and in alignment with one another.

6. Install the FG base plates and set the FGs at the locations indicated. FGs shall be anchored to the station floor and connected to pneumatic airline as indicated. After the FGs are in proper configuration, apply weather proof sealant between the bottom of the FGs and the floor.

7. Install the air compressor as indicated in a vault. The air compressor shall be installed on a slide assembly and installed on top of a TVM leveling plate. For more details, see Standard Drawings J002 and J003.

3.04 TESTING REQUIREMENTS

A. Provide test planning, scheduling, performance, recording of data, and reporting of test results according to Section 01 45 24, Testing Program Requirements.

B. Conduct testing with support from the AFCE Supplier and the District to confirm satisfactory operation after installation and prior to revenue service. Installation testing procedures developed by the AFCE Supplier shall be used.

C. Installation Test

1. Test power and communication cables in each installed AFCE for acceptance by the Engineer. Discrepancies shall be reported to the Engineer and corrected.

   a. Test communication cables (Cat6, DeviceNet, EBO) in accordance with Section 01 45 24, Testing Program Requirements.

b. Test fiber optic cables in accordance with Section 20 70 23, Electronic Circuits, Wires, and Cables.

c. Test grounding system in accordance with Section 26 05 26, Grounding and Bonding for Electrical Systems.

2. Perform installation test on the installed AFCE in accordance with installation test procedures developed by the AFCE Supplier. Testing shall be performed after the equipment is properly installed and secured onsite. Discrepancies shall be reported to the Engineer and corrected.

D. System Integration Test (SIT)

Support SIT. The District will conduct SIT on each installed AFCE in accordance with BART SIT test procedures. The District will also conduct bank certification testing of the credit card function in the TVM/AFM. The SIT and bank certification tests have a duration of three months. Acceptance of the AFCE installation is given upon the District's completion of these tests.

END OF SECTION 34 50 11

SECTION 34 50 13

TICKET VENDING MACHINES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Ticket Vending Machines (TVM)

B. Compatibility with other machines

C. Customer interface and human factors

D. Modes of operation

E. Various assembly requirements

1.02 RELATED SECTIONS

1. 34 50 10 Fare Collection System
2. 34 50 11 Fare Collection Equipment Installation
3. Appendices District Technical Manuals, BART Ticket Specifications

1.03 MEASUREMENT AND PAYMENT

A. Measurement: Ticket vending machines will be measured for payment as a lump sum unit acceptably installed and tested for compliance.

B. Payment: Ticket vending machines will be paid for at the Contract lump sum price for ticket vending machines or as part of the lump sum price for Fare Collection System Work, as determined by the lump sum measurement specified above, as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. Payment Card Industry (PCI) Security Standards Council

1. Pin Transaction Security (PTS) Point of Interaction (POI)
2. Point-to Point Encryption (P2PE) Solution Requirements and Testing Procedures

B. EMVCo (Europay, MasterCard and Visa) Specifications

1. Integrated Chip Card to Terminal Interface
2. Security and Key Management
3. Application

C. Americans with Disabilities Act (ADA)

1. Americans with Disabilities (ADAAG)

D. California Code of Regulations (CCR)

1. CCR, Title 24 California Building Code

E. San Francisco Bay Area Metropolitan Transportation Commission (MTC)

1. Clipper® Card Specification

1.05 SUBMITTALS

A. Refer to Section 34 50 10, Fare Collection System, for submittal requirements.

PART 2 – PRODUCTS

2.01 GENERAL

A. Functionality. The TVM shall perform the following functions:

1. For TVMs supporting magnetic stripe tickets,

   a. Encode and dispense stored value magnetic stripe “BART Blue” tickets, and upgrade a BART Blue ticket with remaining value;

   b. Vend up to five, identical BART Blue tickets in one transaction;

2. For TVMs modified to dispense Clipper® cards, encode and dispense Clipper® cards with regional non-discounted fare category;

3. Add value to a Clipper® Card;

4. Accept cash in one, five, ten, and 20-dollar bills inserted in any orientation with capability to accept bills of other denominations in future; and nickels, dimes, quarters and dollar coins;

5. Accept payment from credit and debit cards with either magnetic stripe and EMV (Europay Mastercard Visa)-compliant chips; contactless payment card; and mobile device;

6. Return nickels, dimes, quarters, and dollar coins and bills for change on cash transactions;

7. Provide change up to $4.95 on a cash transaction. The maximum quantity of change dispensed shall be programmable locally in the service keypad or remotely from Engineering Maintenance Platform (EME); and

8. Make change without purchase for one $1.00 bill.

B. Design for Accessibility. The TVM shall meet all the requirements of the ADA, the ADAAG, and the State of California Code of Regulations Title 24. All operating controls and identification shall be labeled with Braille. The TVM shall be equipped with a voice module with adjustable volume control to allow visually impaired customers to perform any transaction by following interactive voice instructions, both following displayed messages and providing supplemental messages as needed.

C. All operating controls and displays shall be located as indicated in the Contract Drawings.

2.02 COMPATIBILITY

A. Functional Compatibility. The TVM shall be functionally compatible with currently installed AFC equipment to the extent that fare media (tickets and Clipper® cards – See also article 1.07 in Section 34 50 10, Fare Collection System) dispensed from the TVM shall experience no problems in the existing installations due to compatibility, and that fare media dispensed by, or encoded in, the existing equipment shall experience no problems in the new installation.

B. Physical Compatibility. The TVM shall be physically compatible with the existing installation to the extent that a new TVM can be substituted for any existing TVM by simply removing the existing TVM from the vault, leaving the base plate, installing a new TVM on the existing base plate in the vault, and reconnecting power and communication cabling. If necessary, the TVM shall be fitted with filler panels to fully cover the vault opening.

2.03 CUSTOMER INTERFACE AND HUMAN FACTORS

A. Front Panel

1. Human factors evaluation shall be performed on the layout and operation of the Front Panel. Results of the evaluation shall be submitted as a Human Factors Report – TVM for Conceptual Design Review (see Article 1.08.A of Section 34 5010, Fare Collection System).

2. Three meetings shall be held to finalize the front panel design and the display messages. The first meeting shall be held in conjunction with the preliminary design review. The second meeting shall be held in conjunction with the mock-up design review and the third meeting shall be held 150 Days after the start of pre-production field tests on District property. Any changes resulting from these three meetings shall be at no charge to the District.

B. Display Format. The customer shall be guided through fully interactive procedures as opposed to memorized instructions. Graphics and displays shall be easily read under ambient light and direct sun light and shall be easily understood. Graphics, efficient machine timing, appropriate bezel design, and software efficiency shall be employed. Display timing shall permit new instructions to immediately follow customer input. Interfaces with the customer such as visual displays, display format, display language, printed information and instructions, design and location of slots and operating functions, and keypads shall be evaluated by the Supplier and the Engineer. The displays implemented shall be in the English language. Up to

12 user-selectable languages shall be supported for audible and visual messages. The memory reserved for future messages shall be at least three times that initially required for the messages.

C. Alternate Concepts. It is recognized that the Supplier's standard designs and other hardware configurations have an impact on the customer interface and human factors. The Supplier may submit alternate concepts based on consideration of human factors and location of internal components. The Supplier shall identify which features need to stay in a particular location and which features can be relocated. Supplier shall provide alternates for the message display unit (MDU) display messages, and alternates for front panel graphics.

2.04 FRONT PANEL

A. The operating features on the front panel of the TVM are indicated on the Contract Drawings as typical with the features indicated herein.

B. Message Display Unit (MDU): The MDU together with the soft keys and the alpha-numeric keypad shall be the primary means of communication between the TVM and customers.

1. Design: The MDU shall conform to the following design requirements, as a minimum:

   a. Operate in conjunction with the soft keys and the alpha-numeric keypad to provide messages and menus to the customer regarding cash, credit, or debit card transactions, ticket type, and ticket value selection. Where appropriate, multimedia technology shall be used to provide customer instructions and messages. This includes the use of video clips, animation and graphics.

   b. Have a viewing area dimension of at least twelve inches measured on the diagonal and capable of displaying text and graphics.

   c. Employ a high contrast "active matrix" LCD display, or equal. Readability shall be enhanced as required to preclude "washout" in direct sunlight and to minimize glare and reflection. The brightness rating of the display in direct sunlight shall be at least 700 cd/m2. The display shall have a contrast ratio of at least 8:1 in direct sunlight. Displays that focus the light in a narrow band of viewing to enhance privacy are preferred. The viewing angle shall not exceed 30 degrees horizontally from a vertical plane perpendicular to the surface of the screen.

   d. The MDU shall be designed and located so that a customer of height ranging from three feet six inches to six feet nine inches can easily read the instructions. In no case shall the height of the top of the MDU exceed 48 inches from the finished floor.

   e. Be vandal resistant by the use of one-quarter inch transparent polycarbonate front cover panel. The panel shall be attached from the inside of the door and be easily replaceable.

   f. Minimum average life of five years during which the display remains readable.

g. Message contents, font size, and screen layouts shall be easily changeable by parameter modification from BART Central without the need to reprogram the TVM application software.

2. Messages: Messages displayed on the MDU shall be at least 0.4 inch in height. The messages shall be categorized as follows, as a minimum:

a. TVM Status

1) Accepts bills only
2) Accepts coins only
3) Accepts exact change only
4) Accepts credit/debit card only
5) Accepts cash only - no credit/debit cards
6) Transaction canceled
7) No receipts available
8) No BART ticket available
9) No Clipper® card available for purchase
10) No Clipper® card reload available
11) Out-of-Service

b. Transaction Type

1) Cash transaction
2) Card transaction
3) Ticket purchase
4) Ticket purchase with “Remaining Value Ticket” (RVT)
5) Clipper® card purchase
6) Clipper® card reload existing Fare Media

c. Customer Instructions

1) Insert Money
2) Select Credit or Debit Card payment (cash = default)
3) Enter PIN for non-cash payments
4) Media selection (BART Blue or Clipper®) determined by TVM configuration
5) Select ticket value
6) Press “OK” to issue ticket
7) Press cancel

d. TVM Feedback Data

1) Amount of RVT inserted.

2) Amount of money inserted

3) Amount of money due

e. "Other" Messages

1) Transaction approved

2) Transaction not approved

3) No receipt available - continue or cancel

4) See Agent

5) Card type not taken

6) Unable to read card

7) Value not in range

8) Limits exceeded

9) Test transaction approved/not approved

C. PIN Pad. A numeric, tamper-resistant, PIN pad shall be provided on the front panel, located under the MDU in a semi-recessed area for maximum user privacy when using the keypad for PIN entry. The PIN pad shall be used to enter and encrypt PIN required to support the credit/debit feature. The alpha numeric keypad shall be a standard keypad commonly used in the banking industry, with keys for digits from 0 to 9, a star key (*), a pound key (#), a red "Cancel" key in the upper right-hand corner, yellow backspace key and a green "OK" key in the lower right-hand corner. Each key shall have tactile and audible feedback. The keypad shall prevent moisture from getting inside the unit and shall be vandal resistant. The keypad shall be easily removable from the inside of the TVM. The letters, numbers, symbols, and words on the keys shall be wear resistant. The number 5 key shall contain a raised dot to permit recognition by the visually impaired. The keypad shall be shielded so that the PIN entered is not visible to others standing nearby.

D. Soft Keys. A minimum of four stainless steel soft keys shall be located on each side of the MDU as indicated in the Contract Drawings. Each soft key shall be approximately one square inch. Each soft key shall have tactile and audible feedback, and shall have Braille labels. The soft keys shall be used in conjunction with the messages displayed on the MDU, for ticket selection, payment mode, and other customer input required to support the transactions. An acceptable alternative to the soft keys will be the use of a touch screen.

E. Out of Service Annunciator. An "Out of Service" annunciator shall be provided to inform customers when the TVM is out of service. The annunciator shall be a mechanical shutter that drops automatically, or an "Out of Service" message displayed on the MDU. The "Out of Service" annunciator shall be activated, at a minimum, for the following abnormal TVM conditions:

1. Cash boxes not properly in place;

2. Self-diagnostic check failure;

3. Both the cash and credit/debit card operating modes are inoperable;

4. Security breached such as access procedure violated and door open;

5. Door closed but not locked;

6. Ticket and bill/coin jams; and

7. No ticket or Clipper® card stocks.

F. Coin Bezel: The coin slot shall be of the vertical type. The bezel shall be precisely matched to the coin acceptor to prevent diversion of the coin and unnecessary jams, or shall be part of the coin acceptor itself. The shape of the slot and bezel shall minimize accidental deflections of the coins. Size of coin bezel shall limit insertion of coins larger than those legally accepted. Graphical representations of the accepted coin denominations (nickel, dime, quarter and dollar) shall appear below the coin slot as indicated.

G. Coin Return: The coin return cup shall be constructed of stainless steel and formed to enable quick and easy removal of returned coins. The cup shall be, at a minimum, 5-inches wide by 4-inches high by 3-inches deep. An inward swinging transparent polycarbonate plastic cover, 1/8-inch thick minimum, shall be used to prevent coins from spilling out of the cup and to enable the customers to see into the cup. The cover shall prevent access to the TVM internal components via the return cup. Whenever any valid coin is returned, the cup shall be illuminated for approximately five seconds. A series of 1/4-inch holes shall be provided for drainage along the bottom of the cup with a drain tube to carry liquids outside the cabinet, onto the floor in front of the machines.

H. Bill Bezel: TVM shall accept $1, $5, $10 and $20 bills, and other bill denominations in the future. The bill bezel shall be constructed of stainless steel or cast aluminum and formed with a ledge and side guides such that the customer can hold the bill down and slide it into the bill validator entry slot to minimize any tendency to skew. No gaps shall exist between the bezel and entry slot that could divert the bill into the inside of the TVM. The bezel shall be of sufficient strength to withstand minor acts of vandalism and shall be a replaceable module. The bezel shall be designed to reduce and prevent potential for fraud through tampering. Graphics, located on the bezel below the entry slot, shall illustrate the correct orientation of the bill as indicated if such graphics is not on the bill acceptor itself. Graphics shall be engraved unless otherwise approved by the Engineer. The bezel shall not extend more than one and one-quarter inch from the surface of the front panel and shall be affixed directly to the bill validator and not to the front panel. Upon rejection, bills shall be returned through the bill bezel. The bills shall protrude at least two inches, and shall be held until forcibly retrieved by the customer.

I. Bill Return. Upon cancellation of a transaction, the escrowed bills shall be returned through a separate bill return slot. The bills shall protrude at least two inches, and be held until forcibly retrieved by the customer. Transactions requiring change return shall return change with best combination of bills and coins.

J. Ticket Slot. The following functions shall occur at the ticket slot:

1. Dispense BART ticket or Clipper® card and hold for retrieval upon the completion of a ticket or Clipper® card dispensing transaction;

2. Accept BART ticket with RVT of less than a programmed amount (presently set at $11.00) as credit towards a new ticket; and

3. Dispense receipt for a credit/debit card transaction if plain paper ticket stock is used for the receipt.

K. Cancel Button

1. Manual Cancellation. The “CANCEL” button shall allow the customer to cancel a transaction at any time prior to the “OK” button being depressed. Upon cancellation, a “Transaction Cancelled at your Request” message shall blink on the MDU and the money in both escrows shall be returned within three seconds, after which the display shall revert to standby. If an RVT is included in the transaction, the ticket shall also be returned. A beeping sound shall be generated and remain until the returned money and RVT have been retrieved. As soon as the returned money and RVT are retrieved, the TVM shall be ready for use by the next customer.

2. Automatic Cancellation. The “Transaction Canceled” message shall blink on the MDU upon automatic cancellation. A brief message shall indicate the reason for the cancellation. Return of money and RVT, as well as beeping sound shall be the same as for manual cancellation. Conditions that cause automatic cancellation shall include but not be limited to the following:

   a. Maximum coin or bill escrow capacity has been exceeded.

   b. Power failed before the “OK” button to issue ticket was depressed.

   c. More than $1.00 is inserted for a “Change Only” transaction.

   d. Conditions not in accordance with acceptable card transactions as specified herein.

   e. Ticket and bill/coin jams.

3. Reversals. In the event that a ticket cannot be dispensed for an approved credit or debit transaction, such transactions shall be automatically reversed.

4. Front Panel Graphics. Graphics shall be silk screened on a fascia and attached to the front panel as indicated. The fascia shall be secured and vandal resistant. The front panel shall include appropriate graphics to provide the following information:

   a. Types of tickets sold;

   b. Types of payment methods accepted; and

   c. Type of Credit/ATM cards accepted.

L. Receipt Printer. The TVM shall be equipped with a receipt printer that prints a receipt for the following scenarios:

1. Upon request, receipt for a successful credit card or debit card transaction. A cash receipt is not required when the transaction is successful.

2. Receipt for a failed cash transaction for refund claim

3. Receipt for revenue service access

4. Receipt for parking validation transactions

M. Smart Card Reader for Reload: the TVM shall be equipped with a customer-facing smart card reader (see Article 2.14 herein) that allows the customer to add value to an existing Clipper® card.

2.05 TRANSACTION TIMES

A. General: The TVM shall be designed to permit a ticket transaction to occur in a minimum of time. The timing between events is of critical importance. Timing within equipment, between modules and assemblies, between displays, between various steps in the transaction and between transactions shall be implemented efficiently. Bills and coins shall be accepted one after the other without causing the customer to wait between insertions; canceling shall be immediate; displays shall be timed such that the messages or instructions are coordinated with the customer's actions. Transaction times shall be measured in accordance with the transaction step definitions and criteria specified herein. The transaction time for each transaction type shall be measured based on the average of ten transactions conducted by trained personnel. Cash transactions shall be performed using standard street money. Customer interaction times between transaction steps shall not be included in the total transaction times measured as specified. Supplier shall submit the transaction time measurement procedures for review and approval during PDR.

B. Transaction Step Definitions

1. Ticket Issuance: Time from "OK" selection or appearance of bank authorization message on MDU to appearance of ticket at ticket bezel.

2. Coin Acceptance: Time from first coin insertion to total coin value registering on the MDU.

3. Bill Acceptance: Time from bill insertion to bill value registering on the MDU.

4. RVT Acceptance: Time from RVT insertion to appearance of ticket value on the MDU.

5. Fare Media Value Entry: Time from initiation of fare media value correction or selection to appearance of corrected value on the MDU.

6. Change Return: Time from appearance of vended ticket at ticket bezel to appearance of change at the coin tray.

7. Credit/Debit Card Acceptance: Time from credit or debit card insertion or presentation of mobile payment application to appearance of subsequent card transaction screen on the MDU.

8. Payment Method Selection: Time from initiation of payment method selection to appearance of subsequent transaction screen on the MDU.

9. PIN Acceptance: Time from initiation of PIN entry to appearance of subsequent card transaction screen on the MDU.

10. Request/Receive Authorization: Time from appearance of “authorization request” MDU screen to appearance of “transaction approval” MDU screen.

11. Clipper® Card Acceptance: Time from presentation of Clipper® Card to the reader to appearance of Clipper® card value on the MDU.

12. Clipper® Card Reload: For cash transaction, time from “OK” selection to appearance of Clipper® card reloaded message on MDU. For credit/debit transaction, time from appearance of credit or debit card authorization/approval message to appearance of Clipper® Card reloaded message on MDU.

13. Receipt Issuance: If receipt is issued from the ticket bezel, time from removal of the issued ticket to appearance of the receipt at the ticket bezel. If receipt is issued from the coin return tray, time from “OK” selection to appearance of receipt at the coin return tray.

C. Transaction Times. The TVM shall meet the maximum transaction times for the different transactions, as follows:

1. Purchase a ticket using one bill of any denomination ($5, $10, or $20): eight seconds.

2. Purchase a ticket using one nickel, one dime, one quarter, and one bill of any denomination: ten seconds.

3. Upgrade a remaining value ticket with one bill of any denomination ($1, $5, $10, $20): ten seconds

4. Purchase a $4.50 ticket and return the required change using one $5 bill: 15 seconds

5. Purchase a ticket using four bills of any denomination: 15 seconds

6. Purchase a ticket of any value using a credit card: 15 seconds.

7. Purchase a ticket of any value using a debit card: 20 seconds.

8. Reload a Clipper® card using one bill of any denomination: ten seconds.

9. Reload a Clipper® card using a credit card: 15 seconds.

10. Reload a Clipper® card using a debit card: 20 seconds.

D. Reset Times:

1. The time required for the TVM to perform a full logic reset and to return to service after a door closure shall not exceed the time required for the microprocessor operating system to reboot.

2. The time required for the TVM to return to service after a door closure when logic reset is not required shall not exceed ten seconds.

3. For the transactions indicated below, the TVM shall be capable of accepting a customer action to initiate a subsequent transaction within the times indicated:

   a. For ticket purchase or Clipper® card load transaction involving cash, the TVM shall accept a subsequent transaction within 2.0 seconds after the ticket or Clipper® card is taken.

   b. For a ticket purchase or a Clipper® card recharge transaction involving credit/ATM that does not include the issuance of a receipt, the TVM shall accept a subsequent transaction within 1.0 second after the ticket or Clipper® card is taken.

   c. For a ticket purchase or a Clipper® card recharge transaction involving credit/ATM that includes the issuance of a receipt, the TVM shall accept a subsequent transaction within 1.0 second after receipt is taken, or if the receipt is not taken, within 1.0 second after the timeout expires for retrieval of the receipt.

   d. For a ticket upgrade transaction, the TVM shall accept a subsequent transaction within 3.0 seconds after the issued ticket is taken.

   e. For a “Change Giving for $1.00” transaction, the TVM shall accept a subsequent transaction within 2.0 seconds after the required change appears at the coin return cup.

   f. For “canceled” transaction involving cash, the TVM shall accept a subsequent transaction within 1.0 second after the inserted cash is removed from the bill return slot.

   g. For a “canceled” credit/ATM transaction, the TVM shall accept a subsequent transaction within 1.0 second after the cancel button is pressed.

2.06 OPERATING MODES

A. The TVM shall have three basic modes of operation as follows:

1. Primary Mode

   a. Transaction types: The primary mode shall permit the following transactions:

      1) Cash transactions for purchasing or upgrading tickets or for purchasing or loading of the Clipper® card media.

      2) Credit and debit card transactions for purchasing or upgrading tickets or for purchasing or loading of the Clipper® Card.

3) Issue change for a $1.00 bill.

b. Operation: The TVM shall automatically place itself in the correct operating mode depending on the customer's initial action. Once an operating mode is initiated, operation under the other modes shall be prohibited. Initial customer action can be either pressing any key, or in the case of fare media upgrade, a presentation of existing fare media. The Supplier shall develop and submit for approval detailed menu procedures and flow charts to address care of specific rules, additional information, and step-by-step actions such as determining need for change, handling of RVT, confirmation of transaction and restrictions placed on maximum ticket value, minimum ticket value, maximum RVT value, and maximum change permitted. The Supplier shall develop and provide a simulator capable of simulating the graphical user interface on a desktop, laptop, or workstation PC.

1) Ticket Purchase/Upgrade Transaction. The customer shall initiate the ticket transaction by either pressing a soft key to purchase a new ticket, or insert an RVT ticket for a ticket upgrade transaction. The TVM shall recognize this as a ticket transaction and reject any subsequent attempt to process a Clipper® card. A menu-driven format shall appear on the MDU to guide the customer to complete the ticket purchase/upgrade transaction.

2) Clipper® Card Purchase or Add Value Transaction. The customer shall initiate the Clipper® card transaction by either pressing a soft key to purchase a new Clipper® card, or tag an existing Clipper® card to load value on the card. The TVM shall recognize this as a Clipper® transaction and reject any subsequent attempt to process a ticket. A menu-driven format shall appear on the MDU to guide the customer to complete the Clipper® card purchase value load transaction.

3) Transaction Amount Selection. For fare media transactions, a menu-driven format shall appear on the MDU to guide the customer to complete the transaction. If change is desired, the customer shall select the desired transaction value either with the numeric keypad or by increasing/decreasing the value using soft keys. The customer shall then be asked to insert payment in the form of cash or credit/debit card.

4) Payment by Cash. The MDU shall indicate the money required if the selected transaction amount is greater than the money inserted. Insertion of money shall disable any subsequent attempt to use credit/debit cards or mobile payment. The inserted money shall be held in escrow until a valid ticket or Clipper® card appears at the ticket slot, or upon the customer tagging the existing Clipper® card a second time to complete the value load transaction, at which point the money is routed to the money receptacle(s). If the transaction cannot be completed, the TVM shall return the escrowed money to the customer and go out-of-service.

5) Payment by Credit/Debit Card. The MDU shall indicate the money required to complete the transaction. Inserting a credit or debit card shall disable any subsequent attempt to insert cash, and triggers an authorization request to the bank via DAS. Upon receiving real-time authorization from the bank through DAS, a new ticket or Clipper® card shall be issued. For Clipper® card add value transactions, the customer

shall be asked to tag the Clipper® card a second time to complete the transaction. A receipt shall be generated for the completed transaction.

6) Change for $1.00 Transaction. The best combination of change using quarters, dimes, or nickels shall be returned upon the insertion of a $1.00 bill.

7) TVM shall be capable of being configured in Clipper® add-value only mode. If configured, the TVM shall report normal operating status without the need to have any blank fare media in the ticket magazines.

2. Secondary Operating Mode:

a. Transaction types: The secondary mode shall permit the following transactions:

1) Card only - Cash section is inoperable;

2) Cash only - Card section is inoperable;

3) Bills only - Coin section is inoperable; and

4) Exact change only - No change returned.

5) Clipper® add-value only - ticket processing and Clipper® dispensing transactions are disabled. A TVM may enter this secondary mode if blank fare media supply is unexpectedly depleted in the TVM.

b. Operation: The MDU shall indicate the modes within which the TVM is able to operate. The possibilities shall be any of the above transaction types either singly or in combination. The messages “Cash Only”, “Bills Only”, and “Exact Change Only” shall blink on the MDU.

3. Maintenance Mode: Maintenance Mode shall be an operating condition intended for the testing, trouble-shooting and repair of the TVM without the need to use large amounts of coins and banknotes. TVM operation shall be identical to the primary operating mode except as modified herein.

a. Activation of Maintenance Mode. The TVM shall be equipped with switches and an interlocking system that shall be used to activate and deactivate the Maintenance Mode. There shall be three switches:

1) door monitor switch;

2) push to activate momentary contact switch; and

3) pull to activate latching switch.

b. Interlocking: The interlocking system shall operate as follows:

1) With the door opened, the “pull to activate” latching switch shall allow the technician to switch the machine to Maintenance Mode.

2) With the door opened, the “push to activate” switch shall function as a manual logic reset switch.

3) Closing the door shall push the “pull to activate” latching switch to the in position and cause the “push to activate” switch to activate a logic reset. These switch operations shall cause the machine to automatically return

to the revenue mode (provided that all other parameters required for revenue service are satisfied). Maintenance mode shall not be possible with the front door closed.

4) It shall not be possible to close the “Door Monitor Switch” unless the door is physically closed so that the potential of fraud is minimized.

5) Table 1, Logic Table for Maintenance Mode Interlock System, describes the operational status of the machines as a function of the three switches.

Door Monitor Switch	“Push-to-Activate” Momentary Switch	“Pull-to-Activate” Latching Switch	Logic Reset	Machine Mode
Open	Out	In	No	Out of Service
Open	Pushed In	Out	Yes	Maintenance
Open	Out	Out	No	Maintenance Mode
Open	Pushed In	In	Yes	Out of Service
Close	Out	In	No	Revenue. See Note
Close	Pushed In	Out	Yes	Revenue. See Note
Close	Out	Out	No	This Change Shall Not Be Mechanically Possible
Close	Pushed In	In	Yes	Revenue. See Note

Note: Provided that all other parameters required for Revenue mode are satisfied.

Table 1: Logic Table for Maintenance Mode Interlock System

c. Operation. In the Maintenance Mode, the TVM shall be capable of duplicating revenue mode operation with the following exceptions:

1) Only Maintenance (Test) Mode tickets or Clipper® cards shall be issued or accepted.

a) A Maintenance Mode ticket is defined as a ticket with its Maintenance Mode bit set to 1. A ticket with this bit set to 1 shall be accepted by AFC machines only when in the maintenance mode of operation. The words “TEST TICKET” shall be printed in large font on the Maintenance Mode ticket. The test ticket value shall be printed on the first print line.

b) Maintenance mode Clipper® cards are specially encoded Clipper® cards.

2) The inserted bills/coins shall not be captured in the bill/coin vault. The inserted bills/coins shall be held in escrow and returned after the Maintenance Mode ticket has been issued or upgraded. Change shall not be returned in Maintenance Mode, with or without the purchase of a ticket.

3) No registers shall be incremented except for the register that counts the number test tickets dispensed.

4) Credit/debit transactions shall not require approval from the bank. This feature shall allow testing of the credit/debit card reader as well as the credit/debit operation of the machine at the local level. Tickets "purchased" by the credit/debit method shall also be encoded as Maintenance Mode tickets.

5) Clipper card issuance and reloading capabilities shall be verified in maintenance mode. Verification includes both movement of the card within the TVM as well as ability to encode the card. Clipper card used in maintenance mode shall be used in subsequent maintenance mode transactions on TVMs.

d. DAS Interface: When the machine is in Maintenance Mode its status must continue to be reported in real time to DAS using a priority code as defined herein. Ticket or Clipper® card transactions performed in Maintenance Mode shall be reported to DAS in the same format as regular revenue tickets, except that the transaction is identified as a Maintenance Mode transaction.

2.07 MICROPROCESSOR ASSEMBLY

A. The microprocessor assembly shall control operating functions of the TVM. It shall control the performance and timing of other assemblies, sub-assemblies, modules, displays, and serial communications with the DAS.

B. Chip Quality. Microprocessor chips shall have capacity to control operating functions of the TVM ranging from control of displays to slave microprocessors operating in conjunction with a master unit to control and monitor a particular function. Microprocessors shall be of the latest production releases from Intel, AMD or equal.

C. Data Storage

1. Non-volatile RAM Storage. Non-volatile RAM storage shall be provided to store critical data in non-resettable registers as indicated. The RAM storage shall record all sales transaction and equipment status data as they occur, and shall serve as backup in the event of failures in the communication link or the DAS. The RAM storage shall be designed to be polled from DAS and shall allow local extraction of stored data when connected to the PC Notebook, specified in Section 34 50 10, Fare Collection System. The RAM storage shall be divided into two partitions, the "current period" and the "previous period". The current period shall contain all data accumulated since the TVM was last successfully polled by the DAS or by the PC Notebook. The previous period shall contain the last polled data. Upon loss of power, the stored data shall be maintained for at least 30 Days.

2. Hard Disk Storage. As an alternative to the RAM storage, a hard disk or solid-state disk drive may be provided to satisfy the data storage requirements of the TVM. The hard disk shall be designed to operate in a transit system trackside environment and shall conform to the requirements specified for the RAM storage.

3. Data to be Stored

   a. Cumulative Sales Data. Each storage partition (current and previous) shall maintain a record of cumulative sales data consisting of:

      1) Total sales revenue data;
      2) Total revenue from currency by denomination;
      3) Total revenue from debit cards by type;
      4) Total revenue from credit cards by type;
      5) Total number of tickets sold by type and value;
      6) Total number of change-only transactions;
      7) Number of tickets by type sold by currency;
      8) Number of tickets by type sold by each credit/debit card type;
      9) Number of tickets upgraded by ticket type and value;
      10) Number of Clipper® dispensed or reloaded by value; and
      11) Number of Clipper® dispensed or reloaded by payment type.

   b. Individual Sales Transaction Data: Each storage partition (current and previous) shall maintain a record of each individual sales transaction. For each transaction, all applicable information from the following list shall be recorded:

      1) TVM identification number;
      2) Station location;
      3) Date and time of transaction;
      4) Transaction number;
      5) Amount of transaction;
      6) Payment type: Cash, Credit, Debit;
      7) Ticket or Clipper® card serial number;
      8) Currency accepted by denomination;
      9) Coins returned by denomination;
      10) Last 4 digits of the Credit/Debit card number (when applicable). The full credit/debit card number shall not be stored for PCI compliance;
      11) Credit/Debit authorization number (when applicable);
      12) Type and value of fare media vended/reloaded;
      13) Media cost paid (when applicable)
      14) Value of Clipper® card vended or reloaded;
      15) Type and value of ticket to be upgraded;
      16) Value of upgrade;
      17) Value of upgraded ticket;

18) Change only transaction;

19) Coins returned by hopper by denomination;

20) Transaction result, either success or reason for failure; and

21) Clipper® transaction data.

c. Equipment Summary Data: Each storage partition (current and previous) shall maintain a record of Equipment Summary Data consisting of:

1) Number of failure or malfunction incidents by type;

2) Number of access to Bill Vault and Bill Escrow;

3) Number of access to Coin Vault, Coin Hoppers, and Coin Magazines;

4) Number of access to ticket magazine;

5) Number of legitimate entries;

6) Number of intrusions and manipulation entries;

7) Number of accesses to ticket handling mechanism;

8) Number of tickets in reject bin;

9) Number of credit/debit cards not accepted or approved;

10) Number of bills read but not accepted;

11) Number of service and warning incidents by type;

12) Number of tickets remaining in each ticket magazine; and

13) Amount of money in each revenue service component.

d. Equipment Event Data: Each storage partition (current and previous) shall maintain a record of each equipment event, including details for each transaction or media validation failure. For each event, following information shall be recorded:

1) TVM identification number;

2) Station location;

3) Date and time of event;

4) Type of Event;

5) Failure Code;

6) Operator ID, Security Level (if applicable); and

7) Complete financial status of component (if applicable).

4. Storage Capacity: The data storage media (RAM, hard disk or solid-state disk) shall be adequate to store the current and previous cumulative sales data and the equipment summary data for at least 30 Days. For the individual sales transaction data and the equipment event data, the data storage media shall have the capacity to store 10,000 transactions or three days' worth of data, whichever is greater, for both the current and previous period. The Storage media shall be adequate for the storage capacity indicated plus a reserve of 300

percent of the capacity used. If RAM storage is used, expansion shall be possible with the simple addition of memory boards or chips.

5. Data Retrieval: Information in storage shall be transmitted to the DAS or the PC Notebook only upon request and proper authorization. The cumulative sales data and the equipment summary data shall be available locally on the service display upon proper authorization.

D. Data Interface. The data to be transmitted shall include but not be limited to the following:

1. Real Time Data: The data indicated below shall be transmitted to the DAS as soon as the events occur, in real time. The data transmission process shall be accomplished with no degradation to system performance and transaction times.

   a. Event Data:

      1) TVM Identification number;
      2) Station location;
      3) Date, Time;
      4) Operator ID, Security level;
      5) Door open;
      6) Door close;
      7) Maintenance Mode On;
      8) Maintenance Mode Off;
      9) Coin box 85 percent full;
      10) Coin box 100 percent full;
      11) Supplemental hopper 10 percent full (5-cent);
      12) Supplemental hopper 10 percent full (25-cent);
      13) Supplemental hopper empty (5-cent);
      14) Supplemental hopper empty (25-cent);
      15) Bill vault 85 percent full;
      16) Bill vault 100 percent full;
      17) Ticket level low;
      18) TVM in secondary mode; identify mode;
      19) Failure code;
      20) Intrusion Alarm;
      21) Manipulation Alarm;
      22) Reject bin full;
      23) Coin jam;

24) Bill jam;

25) Complete financial status of the TVM every time the TVM door is opened;

26) Indication of low-ticket supply;

27) Indication of low-receipt supply;

28) Performed function code;

29) TVM in-service/out-of-service;

30) Hopper recharged;

31) Authorized entry;

32) Loss of power; and

33) Configuration parameter change.

34) Component status and failure events

b. Individual Sales Transaction Data: The data specified in Article 2.07.C.3.b shall be transmitted.

c. Treasury Service Data:

1) TVM ID number and location

2) Date, Time

3) Operator ID, Security level

4) ID of each revenue service component removed

5) ID of each revenue service component inserted

6) Number and type of bills/coins in each revenue service component removed

7) Unauthorized bill vault or coin box removal or insertion

2. Polled Data. The following data for either the current or previous period shall be transmitted upon request from the DAS, usually outside of revenue service hours:

a. Cumulative Sales Data: The TVM shall transmit the Cumulative Sales Data indicated in Article 2.07C.3.a.

b. Individual Sales Transaction Data: The TVM shall transmit the Individual Sales Transaction Data as indicated in Article 2.07C.3.b.

c. Equipment Summary Data: The TVM shall transmit the Equipment Summary Data indicated in Article 2.07C.3.c.

d. Equipment Event Data: The TVM shall transmit the Equipment Event Data as indicated in Article 2.07C.3.d.

e. Summary of Treasury Services Actions Since Last Poll: For each treasury servicing action since last poll:

1) TVM Identification number;

2) Station location;

3) Date, Time;

4) Operator ID, security level;

5) ID of revenue service component(s) removed;

6) Number and type of bills/coins in each revenue service component when removed; and

7) ID of revenue service component(s) inserted.

E. Service Keyboard. A standard or reduced, internally located alpha-numeric computer keyboard shall be used to communicate with the Microprocessor Assembly. The keyboard shall be used to input such data and commands as security codes, follow menu driven instructions or equivalent aids, retrieve data, and initiate repair routines. Access to Maintenance and Treasury commands/data shall not be possible until a valid security code has been entered.

2.08 TICKET TRANSPORT MODULE

A. General: The ticket transport module shall include the ticket stocks, main transport, and printer as the principal subassemblies. Tickets shall be dispensed from one of two internal ticket supplies to the ticket exit slot. The module shall print the required information on the ticket, and magnetically encode the required information on the magnetic stripe. There shall be at least two ticket supplies in each TVM, both of which will be for the BART Blue Ticket.

Alternatively, the Ticket Vending Machine can be retrofitted to support a Clipper® card transport module to dispense Clipper® cards. The module shall include the card stocks, main transport, and Clipper® card encoder/reader as the principal subassemblies. Clipper® cards (either extended use Clipper® or limited use cards) shall be dispensed from one of two internal card supplies to the ticket exit slot. The main transport shall stop the Clipper® card above the encoder/reader, and encode and verify the card according to the Clipper® card encoding format. The module shall not print on the surface of the smart card. There shall be at least two card supplies in each TVM, supporting extended use Clipper® cards, limited use Clipper® cards, or a combination of both.

B. Fare media supply.

1. The TVM shall be designed to issue the District's standard magnetic stripe tickets or Clipper© cards from die cut ticket stocks. The District's ticket specifications are provided for reference in District Technical Manuals, BART Ticket Specifications.

2. The two magazines shall be readily accessible, removable and replaceable from their mounting; and easily fed into the fare media transport mechanism. Whenever one magazine becomes empty, automatic switching shall occur to enable the main transport to draw fare media from the second magazine if the second magazine is for the same fare media type.

3. Access to the ticket supply magazine shall be protected from unauthorized access and shall require the revenue key.

C. Main Transport (Magnetic stripe ticket)

1. Concept. The main transport shall employ a concept where the ticket is continuously gripped in a positive manner throughout its movement through the various stations until the ticket is dispensed. The main transport shall obtain a ticket from one of the ticket supplies, then to the write head for magnetic encoding, to the verify head to check that the encoding is correct, and to the printer for printing. The write head shall encode security codes and information on the magnetic stripe. The printer shall print the required information on the ticket.

2. Verification of Encoding. The verify head shall authenticate the information encoded on the magnetic stripe. The ticket transport module shall deliver the ticket either to the customer or send it to the reject bin. Upon rejection of the ticket due to incorrect encoding, as determined by the verify head, the TVM shall attempt two more times to deliver a valid ticket. If a valid ticket is not encoded properly and vended after three consecutive attempts, the TVM shall take itself out of service and return the customer's money or reverse the credit/debit card transactions as appropriate.

3. Output Slot: A brake shall be employed at the output end of the main transport to stop and hold the ticket until retrieved by the customer. The output slot shall also be used as an input slot for RVT tickets.

4. Reject Bin. Once a ticket has been accepted as an RVT and a new upgraded ticket has been issued, the value of the RVT shall be reduced to zero value magnetically and four zeros shall be printed in the ticket value column. The RVT shall then be sent to the reject bin. New tickets which fail the read after write test shall also be encoded with a zero value, four zeros shall be printed in the ticket value column, and the ticket shall be sent to the reject bin. Alternatively, instead of the four zeros, the word "void" may be printed in large fonts lengthwise down the remaining value print column of the ticket. The reject bin shall be an easily removable container with a minimum capacity of 1,000 used tickets.

5. Clearing Jams. Jams in all areas of the transport assembly shall be easily removable without the use of tools. The main transport side, which is accessed most frequently to clear ticket jams shall be hinged to allow that entire side to swung open for maximum exposure in clearing jams.

6. No Adjustments. There shall be no adjustments required in the main transport when replacing consumable items such as magnetic read and write heads, and the printer ribbon.

D. Main Transport (Clipper® card)

1. Concept. The main transport shall employ a concept where the Clipper® card is continuously gripped in a positive manner throughout its movement through the various stations until the card is dispensed. The main transport shall obtain a Clipper® card from one of the card supplies, and move it to the embedded smart card reader for RF encoding, and verify the encoding at the same reader. The encoding shall conform with Clipper® card encoding format.

2. Verification of Encoding. The same smart card reader used for encoding shall be used to authenticate the information encoded on the Clipper® card. After the card has been encoded, the card shall remain in the same position above the Clipper® card reader to verify the encoding. The card transport module shall deliver the Clipper® card either to the customer or send it to the reject bin. Upon rejection of the Clipper® card due to incorrect encoding, as determined by the verification step, the TVM shall attempt two more times to deliver a valid smart card. If a valid Clipper® card is not encoded properly and vended after three consecutive attempts, the TVM shall take itself out of service and return the customer's money or reverse the credit/debit card transaction as appropriate.

3. Output Slot: a break shall be employed at the output end of the main transport to stop and hold the Clipper® card until retrieved by the customer. The output slot shall not allow any tickets or Clipper® cards to be inserted.

4. Reject Bin. New Clipper® cards which failed the encoding and verification process shall be encoded with a zero value, and sent to the reject bin. The reject bin shall be an easily removable container with a minimum capacity of 1,000 cards.

5. Clearing Jams. Jams in all areas of the transport assembly shall be easily removable without the use of tools. The main transport side, which is access most frequently to clear card jams, shall be hinged to allow the entire side to be swung option for maximum exposure in clearing jams.

6. No adjustments. There shall be no adjustments required in the main transport when replacing consumable items.

E. Ticket Printer: The ticket printer shall be either a dot-matrix impact printer or a thermal printer and shall meet the following requirements:

1. Print text of different font sizes, and graphics in the printing areas. The printed information shall be easily changeable by parameter modification from EME without the need to reprogram the TVM application software. The printer shall be capable of being configured in the future to print a fifth digit for the hundreds dollar field in the ticket value.

2. Print the following information on issued tickets as indicated:

   a. Ticket Value;

   b. Ticket Serial Number;

   c. Ticket Vend Date;

   d. TVM Identification Number: and

3. Provide clear, "smudge-free" printing. The printing shall be quick drying (for dot-matrix printer), non-fading and erasure resistant.

4. Satisfy the following reliability requirements:

   a. Printer MCBF: 500,000 transactions

b. Print Head Life Expectancy: Greater than 2,000,000 transactions (for dot-matrix printer). Greater than 100,000 feet of thermal paper (for thermal printer).

5. Dot-matrix impact printer, if used, shall employ a field replaceable print ribbon cartridge having the following characteristics:

   a. The print ribbon shall have no noticeable degradation in print quality for at least 250,000 lines of 20 characters per line or six months, whichever occurs first.

   b. The print ribbon shall have a shelf life of at least two years before initiation of degradation.

6. Thermal printer, if used, shall provide image densities of 1.0 or better at 90 degrees centigrade when printing on medium sensitivity papers such as Appleton T922, Ricoh 120TLB, Kanzaki, or equal.

7. Withstand accelerated cycling during testing without overheating, or sustaining damage, or premature failure of any component.

2.09 COIN HANDLING ASSEMBLY

A. General. The coin handling assembly shall include the coin slot, coin acceptor, coin recycling system, coin chutes, coin escrow, coin vault, coin box, supplemental coin hoppers, and coin return cup. The Supplier shall submit procedures and furnish applicable equipment for reconfiguring the coin handling system to accept and verify coins, if different from that specified herein. The procedures and a list of the equipment shall be submitted to the District for approval during the preliminary design review. The coin handling assembly shall:

1. Accept, verify, sort, and store coins inserted for payment, including nickels, dimes, quarters and presidential dollar coins;

2. Dispense coins for transaction requiring coin return. The dispensing rate shall be at least two coins of each denomination per second;

3. Deny access to any of the coins without the use of the revenue key;

4. Deny access to the coin box without the authorized treasury access code and key; and

5. Provide accumulated readings of the coins accepted and dispensed since the last coin box removal. The data shall include quantity and dollar value of each denomination in each revenue service component.

6. Upgradable to accept half dollar, Susan B. Anthony dollar, and presidential dollar coins. The Supplier shall identify and report to BART the current U.S. Department of Treasury coin standards during or before the Preliminary Design Review. The coin handling assembly shall be designed in accordance with these standards.

B. Coin Slot. The coin slot shall be of the vertical type permitting coin denominations of 5, 10, 25-cent and dollar coins to pass without restriction directly into the coin acceptor assembly by the force of gravity. Coins shall go through the coin acceptor for testing. There shall be no transports, conveyors, or other mechanisms employed to move the coin from the coin slot to the input of the coin acceptor assembly. The coin slot shall be normally open so that a cash transaction can be automatically sensed and initiated by insertion of a coin. A mechanical shutter shall be activated to prevent insertion of coins upon initiation of a credit/debit card transaction. The slot shall be sized to physically block the insertion of a 50-cent coin and the simultaneous insertion of two dimes, each at their minimum thickness. The coin slot shall be easily replaceable from the inside of the TVM for a coin slot that will accept a 50-cent coin.

C. Coin Acceptor. The coin acceptor shall be of an electronic type. There shall be both minimal mechanical mechanisms and coins rolling on rails. The coin acceptor shall have proven record of use in fare collection system in a rail rapid transit environment. The coin acceptor shall check each coin to ensure that it meets U.S. Department of Treasury standards with regard to diameter, thickness, metal alloy, and mass. The coin acceptor shall reject counterfeit and foreign coins, tokens, and invalid items such as slugs and washers. Coins detected as invalid, such as bent coins, tokens, slugs, washers, counterfeit coins, and foreign coins shall be diverted directly to the coin return cup.

D. Coin Escrow. Coins shall be held in escrow until the ticket transaction has been completed. The coin escrow capacity shall be at least 20 coins. If the programmed or physical capacity is exceeded, all coins inserted shall be returned and the transaction automatically cancelled. Sensors shall be used to detect a jam in the escrow and to report such an incident.

E. Coin Recycling System. The TVM shall be provided with a coin recycling system to minimize frequency of machine servicing for coin replenishment. The coin recycling shall conform to the following requirements:

1. Receive 5, 10, 25-cent coins and dollar coins from the escrow, if used, or directly from the coin acceptor, and direct the coins to appropriate self-replenishing coin magazines.

2. Dispense 5, 10, 25-cent coins and dollar coins from the coin magazines.

3. Have a capacity of at least 50 coins of each coin type.

4. Dispense coins down to a level of less than five coins of each denomination remaining before a magazine empty signal is given that will require coin dispensing from the supplemental hoppers.

5. Employ a locking scheme that requires the treasury key, security procedure, and proper personnel identification before removal of a coin recycling magazine. Access to coins inside the magazines shall require a revenue key.

6. Dump coins into the coin box upon an authorized command provided that adequate space exists in the coin box.

7. Be able to purge coins from magazines after removal from machine using a purging unit.

8. Communicate with the microprocessor assembly to report specified events and data.

F. Supplemental Coin Hoppers.

1. Supplemental coin hoppers shall serve as backup to the nickel, quarter, and dollar coin denominations supplied from the recycling system. The supplemental coin hoppers shall have minimum capacities of 1,000 for each type of coin.

2. The hoppers shall release coins as change only if coins are not available from the coin recycling system. Once the recycling system receives a prescribed amount of coins of each denomination, the dispensing of coins for change from the supplemental hoppers shall cease until again required as a back-up supply.

3. Supplemental coin hoppers shall be locked to the machine and be removable only using the treasury key and authorized treasury access code. Access to the coins inside the supplemental hopper shall require a revenue key. The TVM shall go into manipulation alarm state if both key and authorized access code are not used.

4. The number of coins in the supplemental hoppers when the hoppers are inserted in the TVM shall default to a predetermined value, that can be set by a treasury service command.

5. The hoppers shall be made of stainless steel, reinforced 18 gauge minimum, all welded construction and provided with about a 4 inches wide by 2 inches deep hinged handle which can support 45 pounds minimum. If a wire handle is used, the handle shall have a minimum diameter of 3/8.” The dimension may be partially achieved by rubberized cushion.

6. Weight, fully loaded, shall be 30 pounds maximum.

7. The electronic ID of a coin hopper shall be automatically recognized upon insertion and recorded in transaction memory and transmitted to DAS in real time.

8. Insertion of a coin hopper with the same ID as one just removed shall be prohibited and shall result in a manipulation alarm.

9. The hopper shall be sufficiently durable to withstand one drop from a height of three feet on concrete, fully loaded, landing on its corner or side, without incurring any damage that would cause access to the coins, or that would prevent its use.

10. All locking mechanisms and electronic components shall be inaccessible from outside the coin box.

11. When locked into their position inside the TVM, the supplemental coin hoppers shall be connected automatically to the microprocessor assembly via an interface. The interface shall be durable to withstand a minimum of 5,000 insertion and removal cycles without degradation in performance, shall be tamper-proof, and shall be easily replaceable with no cutting or resoldering of existing wires and repining of connectors.

12. The hoppers shall be located inside the TVM such that removal and replacement can be performed easily, without causing injury to personnel or damage to components.

13. The coin hoppers shall be designed to permit bag loading or automatic loading and emptying using customized filling machines.

14. The coin hoppers shall communicate with the microprocessor assembly to report specified events and data.

G. Coin Vault. The coin vault shall provide security for the coin box by providing a locked compartment or a locking device. Stainless steel runners and guides shall be employed to enable the coin box to slide freely and to prevent damage to the interface. A coin vault key shall be required for removal of the coin box if it is locked to the coin vault frame.

H. Coin box. The coin box shall conform to the following requirements:

1. Weight, fully loaded, shall be 30 pounds maximum.

2. The electronic ID of the coin box shall be automatically recognized and recorded upon insertion, and transmitted to DAS in real time.

3. Insertion of a coin box with the same ID as one just removed shall be prohibited and shall result in a manipulation alarm.

4. The coin box shall automatically open upon insertion into the TVM to accept coins and shall automatically close and lock upon removal from the TVM.

5. Treasury key and adherence to an appropriate menu shall be required to remove the coin box from the coin vault. Revenue key shall be required to open the coin box to retrieve the coins.

6. Coin box shall be provided with a hinged, non-removable cover and ergonomically designed handles. If wire handles are used, they shall have a minimum diameter of 3/8.” This dimension may be partially achieved by rubberized cushion.

7. The coin box shall be sufficiently durable to withstand one drop from a height of three feet on concrete, fully loaded, landing on its corner or side without incurring any damage that would cause access to the coins.

8. The coin box shall be in place, properly set, and ready to accept coins before the TVM can return to service. A feature shall be provided to indicate that an

inoperable coin box has been inserted and to prevent the incurring of damage that would prevent its use.

9. The coin storage area shall be free of obstructions to permit a 100 percent dump in one attempt.

10. All locking mechanisms and electronic components shall be inaccessible from outside the coin box.

11. When locked into its position, the coin box shall be connected automatically to the microprocessor assembly via an interface. The interface shall be durable to withstand a minimum of 5,000 insertion and withdrawal cycles without degradation in performance, shall be tamper-proof, and shall be easily replaceable with no cutting or resoldering of existing wires and/or repining of existing connectors.

12. The coin box shall be located inside the TVM such that removal and replacement can be performed easily, without causing injury to personnel or damage to components.

13. The time to perform a remove and replace cycle on the coin box shall be less than two minutes, measured from the time the TVM is placed out of service by the action of opening the door, until it is placed back in service and ready for customer use.

14. The coin box shall be furnished with sensors to provide a “near full” signal at approximately the 85 percent level, and a “full” signal at about the 100 percent level. The “full” signal shall cause the TVM to revert to a “Bills or Card Only” mode.

15. The coin box shall have coin space of approximately 300 cubic inches.

16. The coin box shall communicate with the microprocessor assembly to report specified events and data.

I. Coin Chutes. Coin chutes shall be of one piece tubular or boxlike construction using stainless steel of 16 gauge minimum. Access to coins shall be precluded to the extent possible. It shall not be possible to “fish” coin from the coin box. Rejected coins of any kind shall use a dedicated chute that bypasses further checks in the coin acceptor and returns the coin directly to the coin return cup.

2.10 BILL HANDLING MODULE

A. The bill handling module shall include the bill validator, bill escrow, bill box, and the bill vault as required. This module shall be an integral unit that shall be designed, fabricated, and supplied by a single manufacturer. The Supplier shall obtain the current U.S. Department of Treasury standards for one, five, ten, and twenty dollar bills. The bill handling module shall be designed in accordance with these standards. These standards shall be identified in design documents to be submitted to the District before or during the preliminary design review (see Article 1.08A of Section 34 50 10, Fare Collection System).

B. Bill Validator. The bill validator shall:

1. Accept the four denominations of one, five, ten, and 20 dollar bills in any combination, or any one singly. The bill validator shall have the capability to accept at least six additional denominations or bill designs in the future by way of software configuration update.

2. Perform dimensional and optical checks, or dimensional, optical, and magnetic checks to verify bill authenticity.

3. Reject counterfeit, foreign, and copied bills. Return rejected bills and hold until forcibly retrieved.

4. Prevent “milking” by physically blocking the forceful retrieval of a bill already accepted or by preventing the manipulation of two bills or any other fraudulent scheme that would result in a ticket value greater than the actual money received or change being given without capturing the correct bills.

5. Be designed based on technology that has a minimum of two years of proven and satisfactory performance record in a rail rapid transit environment. The Supplier shall provide written evidence and documentation of MCBF and MCBJ in a rail rapid transit environment, and identification of equipment and properties where used.

6. Use software controlled techniques to activate motors to clear a jam using more than one attempt if necessary. This requirement shall apply to the total path of the bill from the bill validator to the bill box.

7. Minimize motor run time. The motor shall be triggered by an inserted bill and the bill automatically drawn in for authenticity checks.

8. Accept input orientation of bills face up with either end first, or bills face down with either end first (4-way).

9. Not initiate dispensing of ticket until all money appears in escrow.

10. Accept at least 95 percent of “street condition” bills in each denomination on the first attempt, and at least 97 percent combined first and second attempt. Street condition bills are bills found in everyday customer use that are not torn, creased, crumbled, folded, or worn beyond what is normally found in street condition bills.

Acceptance percentage shall be assured by the use of self-adjusting system that accounts for differences between bills in circulation caused by production variances and unique aging changes.

11. Have an MCBF greater than 20,000 including jams for bill standards and street money. This figure applies to the entire bill handling assembly.

12. Reject all bills when escrow capacity has been reached.

13. Enable a quick exchange of the unit by the use of quick release fasteners.

14. Set variables or parameters as a bill is being processed in order to reduce the time to start the processing of the following bill.

15. Have a maximum processing time for one bill of 2.0 seconds. The processing time shall be measured from the time the bill is inserted into the bill validator to the time the bill validator is ready to accept the next bill, including communication with and processing time by the CPU. This shall be measured by processing five bills of any denomination in a row.

16. Prevent transport of the bill from the bill validator to the escrow until authentication by the bill validator is completed.

17. Adapt to changes in the bill graphics with only changes to the software. Hardware changes shall not be required unless warranted by dimensional or other physical changes to the bill. The Supplier shall provide a procedure and equipment for reconfiguring the bill validator to accept and verify bills other than those specified above. The procedure and equipment shall be submitted to BART for approval during the preliminary review.

18. Allow direct connection to a manufacturer-supplied diagnostic unit or the PC Notebook specified in Section 34 50 10, Fare Collection System. The PC Notebook or diagnostic unit in conjunction with the validator shall provide data about the operation of the validator. The diagnostic unit shall provide statistics about the units operation.

19. Allow temporary storage of bills to allow bills to be returned as change.

C. Bill Escrow. The bill escrow shall conform to the following requirements:

1. Minimum capacity of 12 bills.

2. Upon cancellation, escrowed bills shall be returned at one time, to a separate bill return slot.

3. Theft of bills shall not be possible without causing major damage to the bill except where access is intentionally provided in order to free a bill jam.

4. Bills in escrow shall not be affected by rejected bills.

5. Escrowed bills shall be returned upon insertion of an excessive number of bills.

6. Transfer the bills to the bill stacker upon command to issue a ticket. No bill shall be inserted in the bill stacker without being registered and recorded in the data storage memory.

D. Bill Vault. The bill vault shall be a locked enclosure containing and providing security for the bill box. The steel design and construction of the vault shall deter forced entry. The treasury key and a security procedure shall be required to open the vault. Machine shall go to a manipulation alarm state if either a treasury key or authorized access code are not used. The access door shall be hinged or on slides and not removable. At least one mounting bolt that holds the vault to its mounting panel shall be located inside the vault. The other half of the interface connector for the bill box shall be located inside the vault. The electronic ID of a bill box shall be automatically recognized upon insertion and recorded in transaction memory and transmitted to DAS in real time. An acceptable alternative to the bill vault is locking the bill box directly to its locking device and connector interface, affixed in a secure manner to the TVM.

E. Bill Box. The bill box shall conform to the requirements specified above for the coin box, and the following:

1. Constructed of stainless steel and durable to the extent that dropping of the bill box from a height of four feet above a structural concrete floor and landing on its weakest areas, edges, or points after ten drops shall not cause access to the bills. When dropped empty, or full, the bill box shall not open.

2. Weight, fully loaded, 20 pounds maximum.

3. The handle shall hold 30 pounds.

4. The bill box shall cause the CPU to record and report specified events and data to DAS in real time upon removal.

F. Bill Stacker. The bill stacker shall be located inside the bill box. The bill stacker shall receive unfolded bills from escrow in a neatly stacked, forceful manner. Bills shall not be trapped, torn, or otherwise mishandled while being stacked. The stacker shall be an internal and easily removable section of the bill box. The capacity shall be a minimum of 2,000 “street” bills. The design shall permit quick and easy removal of the bills from the stacker in a manner that reduces the handling time required to prepare the bills for counting in the District’s bill counting equipment. The time to remove and to replace the bill stacker from and back into the bill box shall not exceed five seconds, including unlocking and relocking the bill box.

2.11 CREDIT/DEBIT CARD MODULE

A. The credit/debit card module shall consist of a card reader and card control electronics, and shall employ the numeric keypad, the soft keys, and the receipt printer for transactions. The card module shall conform to the following requirements:

B. Credit/Debit (Payment) Card Reader:

1. The card reader shall be PCI-compliant and EMV level-1 and level-2 certified. It shall be able to read magnetically encoded and contact/contactless EVM credit and debit cards; payment applications on mobile devices; and maintenance access cards.

2. The card reader shall read and verify information on credit and debit cards encoded in accordance with current applicable ISO and EMV standards. The reading of the magnetic stripe tracks shall be accomplished by a manual movement of the card passing through fixed heads. The reading of the data encoded in the EMV chip shall be accomplished by leaving the EMV-compliant card in the card reader slot for the duration of the credit card transaction. The reader shall be installed as specified by manufacturer to avoid involuntary contactless readings.

3. The card reader shall have a reliability of at least 50,000 cycles between failures with the reader processing at least 10,000 credit/debit cards per month. Evidence of successful performance in current operating equipment shall be submitted.

4. The card reader shall be capable of reading 99.9 percent of properly inserted cards.

5. The instructional graphic associated with the card reader shall show the location of the magnetic stripe or the EVM chip contact to explain to the customer the required card orientation. The mounting of the card reader shall prevent accumulation of fluids inside the reader.

6. The card reader shall be capable of detecting insertion of card to initiate transaction and close bill/coin shutters.

7. The PIN pad shall have shielding to prevent anyone other than the customer from seeing the PIN being entered by the customer.

C. Card Transaction: The credit/debit module shall operate in conjunction with the MDU, the soft keys and the numeric keypad if applicable to guide the customer through a transaction. The numeric keypad shall encrypt customer input PIN number. Utilizing unique keys per transaction and managing master keys shall be as specified in PCI PTS (PIN Transaction Security) POI (Point of Interaction) approval framework.

D. Point to Point Encryption (P2PE) Compliance:

1. The credit/debit card module shall comply with PCI P2PE standards.

2. The credit/debit card module shall be able to function between a non P2PE mode and a P2PE mode, and switching from non-P2PE to P2PE mode shall be made available through a software configuration.

3. A non P2PE mode shall remain to function as it is today, and P2PE mode shall function to support P2PE.

4. The P2PE functions implemented shall be designed to work for both of the traditional magnetic debit/credit cards and the EMV debit/credit cards.

5. The TVM software shall prepare P2PE data in formats complying with and meeting requirements of a P2PE solution chosen by the District.

6. The protocol used to support and send P2PE data to DAS shall be modified from the current VEI/EIS protocol in such a way that minimum modification effort is needed from the District to modify DAS.

7. District shall be consulted, and will make final decision for modification of the VEI/EIS protocol.

8. District will modify DAS to interface with a bank to support P2PE.

E. Card Control Electronics: PCI-compliant, level-1 and level-2 certified by EMVCo and conform to the following requirements:

1. Accept credit cards from VISA, MasterCard, American Express and Discover, and provide the capability to accept credit cards from other networks by means of easy configuration.

2. Accept debit cards from Interlink and Explore, and provide the capability to accept debit cards from other networks by means of easy configuration.

3. Read and transmit card information to DAS, which sends it to the financial institution and requests authorization.

4. Prohibit the insertion of cash upon the insertion and recognition of one of the accepted cards.

5. Permit the balance remaining on a magnetic stripe ticket to be credited towards the purchase of higher value ticket, if the balance is within prescribed limits.

6. Display the necessary steps in an operational sequence to permit purchase of a ticket in the minimum amount of time.

7. Require acknowledgment of the purchase price.

8. Permit canceling of the transaction or changes to the ticket value up to the point of acknowledgment of the ticket value. Once ticket value is approved the request for authorization shall be sent immediately.

9. Limit ticket values to the initial range of $2.00 minimum to $300.00 maximum in $1.00 increments. Limits shall be easily changed remotely from EME or locally using the PC Notebook.

10. Cause automatic cancellation of the transaction under the following conditions:

    a. Authorization from the DAS is negative, including velocity checking and payment processor or issuer denials.

b. Valid ticket or Clipper® card cannot be dispensed.

c. Procedural constraints are violated.

d. Magnetic tickets inserted for credit are invalid.

e. PIN is invalid after three attempts within a prescribed time period. The time period shall be adjustable from 3 to 30 seconds in one second increments. When exceeded, the display shall indicate the reason and return to the standby mode.

f. Upon loss of power/DAS communications.

g. Customer walkway prior to the completion of the transaction.

11. Display to customer the reason for cancellation.

12. Cause the TVM to automatically return to the standby mode and be ready to perform the next transaction after an automatic cancellation.

13. The PIN entry device shall encrypt PIN block data prior to transmission over communication lines. The encryption process (i.e., Derived Unique Key per Transaction) and encryption key management shall conform to latest PCI PTS POI requirements.

14. Request approval of credit/debit transactions in real time from the DAS. Once a successful read of the credit or debit card has been achieved, a PIN has been entered when required, and the transaction value selected, the TVM shall pass the transaction information to the transaction processor through the DAS for immediate approval by the banking network. Transaction requests shall take priority over all non-security related TVM transmissions.

15. The card control electronics may consist of electronics in the OEM card reader found to be useful plus the electronics, memory, and chips in the microprocessor assembly that are devoted to a card transaction.

16. Screen messages and receipts related to credit and debit transactions are subject to the approval of the financial institution that BART uses to process these transactions, and will not be considered complete and accepted until approved by BART and the financial institution.

17. Issue the purchased fare media after notification by DAS of authorization of a pending sale.

18. Notify DAS only upon successfully issuing the purchased fare media of a transaction completion.

19. Cancel a pending sale to DAS if the fare media cannot be successfully vended.

20. If requested by the customer through the use of an on-screen prompt, issue a receipt after a ticket has been successfully vended.

21. Accept EMV compliant cards.

22. Read test credit/debit cards and Clipper® Cards and transmit card information to DAS, and receive and display test transaction response messages from DAS.

F. Receipt Printing

1. If requested by the customer, a printed receipt shall be provided on credit/debit card transactions. The receipt shall contain the information required to comply with the “Electronic Fund Transfer Act” as promulgated in the latest revision of Federal Reserve Board, Regulation E, and required by the banking industry including Visa, MasterCard, American Express, and Discover. As a minimum, the information shall include:

    a. The wording “receipt”;

    b. Date and time of purchase;

    c. TVM ID Number;

    d. “BART” and the TVM station location;

    e. The words “debit card sale” or “credit card sale”;

    f. Credit card type (e.g., Visa, MasterCard, American Express or Discover);

    g. Dollar amount of the transaction;

    h. Transaction authorization and reference number;

    i. Ticket or Clipper® card serial number;

    j. Credit/debit card number truncated to display only the last four digits;

    k. Credit/debit card expiration date;

    l. If debit, an indication that it is from primary account;

    m. Transaction type (credit or debit);

    n. Type of fare media vended or reload (BART Ticket, Clipper® Card);

    o. Amount of the transaction paid towards the cost of the fare media; and

    p. Amount of the transaction paid towards the value loaded onto the fare media card/account balance

2. If blank paper ticket stock (no magnetic stripe) is used for the receipt, the receipt shall be issued from the same printer that is used to print tickets, and shall be issued from the same slot as the ticket within two seconds after the issued fare media is retrieved.

3. The roll stock for the receipts shall have the capacity to issue at least 1,000 receipts.

2.12 FRONT PANEL MOCK-UP

A. A mock-up shall be provided of the TVM front panel. If actual equipment and construction materials are unavailable for use in the front panel mock-up, the mock-up shall be constructed of material that will retain its shape for the duration of the mock-up evaluation period. The mock-up shall be identical in dimensional details of all the features and approximate in color and texture and shall include all graphics printing and simulated or actual displays. Samples shall be provided for such items as the front panel surface, keypad, decals and MDU to be used. The mock-up shall be self-standing with the front panel vertical and at the exact height above the floor as the production equipment. The mock-up shall become the property of the District upon delivery. No warranty shall apply to the panel mock-up after acceptance by the District.

2.13 DOWNLOADING

A. Commands and parameters issued to the TVM from DAS or EME shall include but not be limited to the following:

1. Real-Time Commands issued from DAS

    a. Reset/synchronize time/date information.

    b. Initiate self-diagnostic operations.

    c. In-service/out-of-service control.

    d. Request for polled data.

    e. Enabling/Disabling payment types (i.e. card only, credit/ATM only).

    f. Enabling/Disabling bill/coin denomination.

2. Software/Parameter Downloads from EME

    a. Transaction menu contents and formats.

    b. Ticket type and sales period (i.e. first 5 days of month for BART PLUS).

    c. Frequency of data recording and transmission.

    d. Modification of TVM variables such as; minimum fare, RVT maximum value, maximum ticket value, time between events, quantity and denomination of change given. Ability to read back TVM variables including any downloaded parameter, and current operational state of the equipment.

    e. Security code assignments for access to specific components.

    f. PIN assignments for equipment access.

    g. Ticket type to accept/reject.

    h. Set automatic vs. optional issuance of receipt for credit/ATM transaction.

    i. Software/firmware upgraded for all supported components.

    j. Clipper® configuration parameters.

k. Ticket negative list.

2.14 SMART CARD READER

A. The external facing smart card reader shall communicate with the Clipper® Smart Card fare media. Additional internal smart card reader/encoder may be required and provided to encode new Clipper® cards for issuance.

B. Clipper® card transaction data shall be stored in the TVM and reported to DAS in accordance with the requirements specified in Article 2.07 herein. Read and reload the Clipper® cards. Real-time commands and parameter downloads shall be received from DAS.

C. The card reader/encoder, on the outside of the TVM shall be clearly marked with the color logo of the Clipper® Card. The logo will be furnished by the Engineer to the Supplier at PDR.

2.15 TREASURY SERVICE RECEIPT

A. Receipt Information: Upon completion of service by the revenue service staff, the TVM shall issue a receipt with the following information as a minimum:

1. TVM identification number
2. Station location
3. Date
4. Time when door was first opened
5. Time upon completion of revenue service
6. ID number of all revenue service components removed from TVM
7. ID number of all revenue service components inserted in TVM
8. Operator identification and security level

B. Information on the content of the revenue service components shall not be printed on the receipt.

2.16 AUDIO

A. For the visually impaired, pressing a “Push for Audio” button shall cause audio announcements of the information on the MDU and shall guide the customer through all possible transactions using interactive voice instructions supplemental to those displayed on the MDU. Adjustment of the volume to the desired level shall be possible from the outside of the machine, with automatic reset to the preset level upon completion of a transaction. Quality of the enunciation shall be subject to approval by the Engineer.

2.17 TVM EXTERNAL SECURITY AND INTRUSION ALARM

A. An external security access feature shall be included in the TVM to authorize a valid request for machine entry. Without authorization, any attempt to open the equipment door on the TVM shall result in an intrusion alarm.

B. The external security access feature shall use an encoded contactless card or magnetic stripe card encoded with the PIN security code and associated access levels, a unique card serial number with a minimum of six digits, and an employee serial number with a minimum of 6 digits or equivalent. A mutually acceptable encoding format shall be determined during the equipment design period. The Supplier shall furnish 2,000 cards encoded with specific information as directed by the Engineer. The Supplier shall provide the cards and the equipment for encoding the cards and maintaining the PIN database.

C. The card will be inserted and removed by an employee, into and from the credit/debit card reader or smart card reader of the TVM, followed by a Personal Identification Number (PIN) entry on the numeric keypad. The PIN shall be validated by the TVM by checking if the PIN is compatible to data stored in local memory. An authorized card/PIN combination, shall result in a response back to the user, authorizing the employee to open the door. The door will be opened by the employee by unlocking the key lock to operate the equipment door handle. The door locking mechanism shall not contain mechanical or electrical interlocking to interface with the external security system.

D. An unauthorized card/PIN combination combined with an open door detection (unauthorized door opening), shall immediately activate an intrusion alarm. Repeated failure (more than three attempts) to enter a valid PIN within a predetermined time shall also activate an immediate intrusion alarm.

E. The cycle time from activation of the equipment access hardware to a displayed feedback to the user shall be user selectable and programmable.

F. The TVM shall log and store in the machine all door openings and access attempts along with the access date and time as well as the card and employee numbers read from the access card. Access information will be recorded regardless of the success of the access attempt. Access information shall be output to the DAS on a real-time basis and stored in RAM.

G. The Engineer will furnish the data for development of the card/PIN database. The database shall be such that it can be modified or upgraded remotely and it shall be capable of being downloaded to the individual TVMs from the Treasury Office Workstation (TOW), which is part of the EME platform. Local data storage capacity shall be at least 2000 PINs and associated data. The local database shall be capable of storing and recognizing specific card/PIN combinations which may be labeled as “bad” and downloaded to the TVM from TOW. Recognition of a card/PIN combination not in the local database or a “bad” card/PIN combination by the machine’s processor shall cause the TVM to request a repeat entry of the PIN. Repeat failure (more than three attempts) to enter a valid PIN within a predetermined time shall activate an immediate intrusion alarm.

H. An intrusion alarm shall result in a local audible alarm annunciation in the equipment and remote intrusion alarms being sent by the TVM to the DAS and to the hardwired communication interface.

1. The TVM intrusion alarm output shall:

   a. Be independent of any annunciations or alarm messages that are sent to the DAS or to the hardwired communication Interface.

   b. Include a direct interlock to the incoming power supply that annunciates upon loss of power (Output to the hardwired communication interface and the DAS).

   c. Require the TVM microprocessor assembly to reset a watchdog timer periodically to prevent an intrusion alarm when none exists and to additionally generate an annunciation in the event of primary CPU failure (Output to the hardwired communication Interface and the DAS).

   d. Detect and annunciate upon a failure of security related components or a corruption of the card PIN database (Output to the hardwired communication interface and the DAS).

   e. Annunciate upon an unauthorized door opening (Output to the hardwired communication interface and the DAS).

2. The system shall be programmed to detect and annunciate access to modules or assemblies not allowed by an authorization level based on the card data and associated PIN, i.e., “work performance within an unauthorized work area”. The Engineer will supply a list of monitored modules and assemblies with the allowable access of each category of personnel (Output to the Hardwired Communication Interface and the DAS).

3. Remote alarms shall reset after the equipment has been repaired and/or returned to the proper security level.

4. In the event of loss of station power or communication with DAS, or upon failures of the locking mechanism itself to operate, the Supplier shall provide means to open the TVM without compromising the security of the machine.

2.18 POWER SUPPLY MANAGEMENT

A. The TVM shall be designed with the following power supply management features:

1. Power Switches: The power supply connections to all major assemblies/modules shall be equipped with in-line power switches to allow each assembly/module to be powered down separately without interrupting power to the CPU. The switches shall be securely mounted and easily accessible. The switches shall be labeled and shall be of heavy-duty construction capable of sustaining repeated operations without breaking, cracking or degradation in performance. The assemblies/modules requiring in-line power switches shall include but not be limited to the following:

   a. Microprocessor assembly

b. Ticket transport module

c. Coin handling assembly

d. Bill handling module

e. Credit/debit card module

f. Message display unit

2. Back-up Battery: The TVM shall be equipped with battery back-up to complete the transaction in progress and to maintain power to the microprocessor assembly for 30 minutes in the event of a station power loss or deactivation of the TVM main power switch. Upon sensing either of these conditions, the TVM shall report a real-time “loss of power” alarm to DAS. The back-up battery shall operate constantly off a trickle charge between power failures.

PART 3 – EXECUTION

For installation refer to Section 34 50 11, Fare Collection Equipment Installation.

END OF SECTION 34 50 13

SECTION 34 50 16

FARE GATES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Consoles: entry, exit, reversible and accessible consoles.

B. Gate aisles.

C. Reversible Consoles Gate arrays.

1.02 RELATED SECTIONS

A. 34 50 10, Fare Collection System

B. 34 50 11, Fare Collection Equipment Installation

C. 34 50 13, Ticket Vending Machines

D. 34 50 19, Add Fare Machines

E. Appendices, District Technical Manuals, SCADA System Function Description

1.03 MEASUREMENT AND PAYMENT

A. Measurement: Fare gates will be measured for payment as a lump sum unit acceptably installed and tested for compliance.

B. Payment: Fare gates will be paid for at the Contract lump sum price for fare gates or as part of the lump sum price for Fare Collection System Work, as determined by the lump sum measurement specified above, as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM A240/A240M Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications

2. ASTM A269/A269M Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service

B. Americans With Disabilities Act (ADA):

1. Americans with Disabilities Act Accessibility Guidelines (ADAAG).

C. California Code of Regulations (CCR):

1. Title 24 California Building Standards Code

D. Metropolitan Transportation Commission (MTC):

1. Clipper® Card Specification

1.05 SUBMITTALS

A. Refer to Section 34 50 10, Fare Collection System, for submittal requirements.

PART 2 – PRODUCTS

2.01 GENERAL

A. The fare gates separate the free areas in a station from the paid areas, and control entry of patrons into the system, time within the system, fare required, and exit from the system.

1. Console: a cabinet with a fare processing mechanism and barrier leaf/leaves. Two consoles shall be used to form an aisle and a gate barrier system (See Article 2.07 herein). There shall be four types of gate consoles as follows:

   a. Entry consoles (E) are installed on the right side of an array when viewed from the free area. The entry consoles shall be equipped with an Entry Ticket Processing Module, one Smart Card Interface Device (CID) and one half of a barrier system.

   b. Exit consoles (X) are installed on the left side of an array when viewed from the free area. The exit consoles shall be equipped with an Exit Ticket Processing Module, one CID, and one half of a barrier system.

   c. Reversible consoles (R) are installed between the entry and exit consoles in the quantities required. The reversible consoles shall be equipped with an entry ticket processing module, an exit ticket processing module, one CID at each end, and two halves of a barrier system.

   d. Accessible Consoles are installed at the end of a fare gate array either adjacent to an entry or exit gate, or adjacent to a “dummy console” separated from any fare gate array to form a standalone wide aisle for customers in wheelchairs. The accessible fare gates (AFG) are bidirectional and shall be able to process both entry and exit transaction in any sequence without the need to change directions.

2. Gate Aisle: a passageway formed by two adjacent consoles, hence guarded by two barrier leaves. The width of the aisle, which is the distance between the two adjacent consoles, shall be as indicated in the Contract Drawings. Aisles shall be reversible.

3. Gate Array: A typical array shall consist of one E console, one X console and in between a minimum of one R console forming at least two aisles. A three-aisle array shall consist of one E console, one X console and two R consoles. AFGs shall be located at the end of selected gate arrays adjacent to either the entry or exit gate.

4. Customer Flow Rate: Entry and exit gates shall be able to process customers at a minimum rate of 30 persons per minute, assuming trained customers, valid tickets or smart cards and no ticket replacement for 21 print lines.

2.02 TICKET INSERTION

A. Ticket Insertion Bezel: The ticket insertion throat height shall be between 35 and 37 inches above the finished floor. The ticket insertion throat shall be located at least two inches above the bottom of the sloped face of the fare gate. Sufficient space shall be provided below the ticket bezel on the sloped face of the fare gate to allow for ticket orientation graphic specified in Article 2.03 herein.

B. Ticket orientation when inserted into the ticket slot of the console shall be such that the magnetic stripe is on the top face and along the right edge of the ticket. The ticket contains an arrow on top to indicate the correct orientation and an orientation hole for use by the visually impaired and for use by the electronics to identify and detect proper insertion. Tickets improperly inserted shall be rejected and returned to the customer without processing.

2.03 GRAPHICS AND DISPLAYS

A. Graphics. The graphics shall consist of the ticket orientation picture engraved below the entry bezel and the words “Insert Ticket as Shown” engraved above the bezel.

B. End Displays. The displays shall be latent and shall become visible only upon electrical illumination for the following indications:

1. International symbol for “Entry Prohibited” - a red circular display or a red “X” located at each end to alert the customer not to use that particular aisle as indicated.

2. International symbol for “Entry” - a green display including an arrow pointing to the 10 o’clock position to inform the customer to use that particular aisle to enter or exit the system as indicated.

3. Both symbols shall be cycled on-and-off to indicate the use of a discounted fare media, including senior, youth, disabled and student magnetic tickets and Clipper® cards. The timing and duty cycle shall be configured over the network via the EME.

C. Ticket Insertion Display. The ticket insertion display shall be located on the top of the console near the ticket entry slot as indicated in the Contract Drawings. The illumination devices used for the display shall be high intensity Light Emitting Diodes (LED) or equivalent designed to maximize visibility under all light conditions. The display shall be latent and shall become visible only upon electrical illumination for the following indications:

1. “Insert as Shown” - a flashing red message that is displayed whenever the ticket is inserted incorrectly. It shall remain displayed until the customer removes the ticket from the entry slot.

2. “Out of Service” - a red message that shall be displayed to prevent the use of a particular aisle or a particular direction for that aisle. This means that a reversible console can be “Out of Service” at one end, but “In Service” at the other end. The corresponding end message for Entry Prohibited shall also be displayed.

D. Ticket Status Display. The ticket status display shall be located on the top of the gate console near the ticket return slot as indicated in the Contract Drawings. The illumination devices used for the display shall be high intensity Liquid Crystal Display (LCD) or equivalent designed to maximize visibility under all light conditions. The display shall be latent and become visible only upon electrical illumination for the following indications:

1. “Take Ticket” - a flashing white message that is displayed to inform the customer to retrieve the ticket from the exit slot and remains displayed until removal of the ticket. Deducted fare and remaining value shall be displayed.

2. “See Agent” - a flashing red message that is displayed whenever the ticket or smart card cannot be processed in the normal manner.

3. “Underpaid - Go to Addfare” - a flashing red message that is displayed on exit gate consoles only when the ticket or smart card has less value than the fare for the ride just completed.

4. “Exact Fare - Ticket Not Returned” - a flashing white message that is displayed only on exit gate consoles when the value of the magnetic ticket is equal to the fare for the ride just completed.

5. “Insufficient Value - Go to Vendor” - a flashing red message that is displayed on entry gates when the ticket or smart card has less than the minimum ticket value required to enter the system.

6. “OK” – a white message indicating successful processing of a fare media without stored value, such as BART employee pass.

E. Performance Requirements of Ticket Insertion Display and Ticket Status Display.

1. The displays shall have a viewing angle of at least 60 degrees measured from a perpendicular axis at the center of the display.

2. LED illumination, changes in state, and location of messages shall be visible to a person with normal vision at a distance of ten feet from the display.

3. The size of the latent display characters shall be at least 0.2 inch wide by 0.3 inch tall.

4. The timing and duty cycle of the flashing messages shall be easily programmable from EME or the PC Notebook.

5. The size of the programmable display characters shall be at least 0.2 inch wide by 0.3 inch tall. The text, timing and duty cycle of the programmable display messages shall be easily programmable from DAS (see Section 34 50 10, Fare Collection System) or the PC Notebook.

6. The displays shall be vandal resistant by the use of scratch and impact resistant transparent polycarbonate.

7. The LED illumination devices shall be mounted in horizontal and vertical rows in modules, which shall be the lowest level of field replaceable unit, to meet the modular design requirements of the Specifications.

2.04 ENTRY TICKET PROCESSING MODULE

A. To enter the BART system and to go from the station free area into the paid area, a customer shall be required to insert a ticket in an entry ticket processing module or tag a contactless fare payment media on the CID. The District will provide complete ticket processing information to the Supplier after Contract award and upon execution of a confidentiality agreement. The entry ticket processing module shall process tickets as follows:

1. Ticket Insertion: Upon insertion of a ticket in the ticket bezel, the transport assembly shall check for proper ticket orientation by detecting the presence of the orientation hole to verify proper ticket insertion, and move the ticket to a “read” station for a validity check. If a ticket without the orientation hole in the proper location is presented into the bezel, it shall not be accepted, and the message “Insert as shown” shall flash on the display. The “Insert as Shown” shall flash as long as the item remains in the entry bezel and shall turn off once the item is removed.

2. Validity Check: The ticket’s magnetically encoded data shall be checked for validity. If the ticket is not valid, it shall be returned unaltered to the customer through the exit slot with the message “See Agent” flashing on the display, and the barriers shall remain closed. The validity check shall include:

    a. Check ticket type;

    b. Value greater or equal to the minimum fare on a BART Blue ticket, or greater or equal to $0.05 ticket on a Student ticket;

    c. Differentiate between revenue ticket and maintenance mode ticket; and

    d. Ticket coded for entry. See “Entry/Exit Code” section below.

3. Encoded Data: If the ticket is valid, the transport assembly shall move it to the "write" station where entry data shall be encoded at the specified locations on the magnetic stripe. The entry data shall include the time and day codes, the ready for exit code, and the station of entry code.

4. Verification of Encoding: The transport assembly shall move the newly encoded ticket to a "verify" station to verify the encoded data. If the verification fails, the ticket shall be returned to the customer and the message "See Agent" shall flash on the display. If three "write" failures occur consecutively, the console shall place itself in "Out of Service" mode.

5. Ticket Return: If the verification check is valid, the transport assembly shall move the ticket to the exit slot and the message "Take Ticket" shall be shown on the display. The ticket shall protrude approximately 1.5 inches above the top of the console in the exit bezel and shall be held in place by a holding brake until it is retrieved by the customer.

6. Alternative to a magnetic stripe ticket, the customer may tag a smart card on the CID to initiate entry transaction at the fare gate. The customer shall leave the card on the CID for the duration of the transaction. The same validity checks and encoding for magnetic tickets shall apply for smart cards, modified to accommodate the technical differences between tickets and smart cards.

7. The fare gate shall provide audible indication:

    a. Two seconds after the smart card has been successfully processed for entry and is still tagged,

    b. If balance falls below a pre-stablished threshold, and

    c. When it fails to process the card.

8. Discount fare media indication. When ticket type or card type is acquired from the fare media, the fare gate shall visually indicate the discounted ticket type, including senior, youth or disabled tickets. The visual indication shall be visible on the End Display for an individual standing 20 feet away from the fare gate either in the entry or exit direction of the fare gate.

9. Barrier Opening: Upon retrieval of the protruding ticket by the customer, or the completion of a smart card transaction, the barriers shall open and the message "Take Ticket" shall be turned off. The ticket processing cycle, from ticket insertion to ticket removal and barrier opening, shall permit smooth, continuous passage of the customer without unnecessary stops or delays.

10. Entry/Exit Code: The entry gate shall accept entry-coded tickets only. If there is a fault with the ticket/smart card encoding or if such occurrences as excessive train delays caused the customer to abandon their journey resulting in an exit-coded ticket or smart card, an entry/exit override capability shall be given to the station agent. The override command shall make the entry ticket processing module ignore the entry/exit coding check at the entry gate and allow the customer to enter the system with an otherwise valid ticket or smart card. It shall be possible for DAS and EME (see Section 34 50 10, Fare Collection System) to override the entry/exit code check, and to disable an active override condition.

11. Out of Service: When the console is not functioning properly and is in its out of service mode, the message “Out of Service” shall be displayed on top of the console and the corresponding End Display for Entry Prohibited shall be lit. In this mode, the console shall not accept a ticket into its transport nor accept a smart card tag.

2.05 EXIT TICKET PROCESSING MODULE

A. To exit the BART system and to go from the station paid area into the free area, a customer shall be required to insert a ticket into an exit console ticket processing module, or tag a contactless fare payment media on the CID. The exit ticket processing module shall process tickets as follows:

1. Ticket Insertion. The process is the same as that for the entry ticket processing module.

2. Validity Check and Fare Calculation: The read station shall decode the information encoded on the magnetic stripe. The magnetically encoded data shall be checked for validity including:

    a. If the ticket is not encoded as “ready for exit”, it shall be returned unaltered to the customer thru the exit slot and the message “See Agent” shall be displayed. The barriers shall remain closed.

    b. If the patron time within the system exceeds the allowable limit, the ticket shall be returned unaltered to the customer through the exit slot and the message “See Agent” shall be displayed the barriers shall remain closed. See “Date/Time Code” section below.

    c. If the ticket is encoded as “ready for exit” and the travel time does not exceed the time limit, the exit console shall determine the fare as required. Each exit logic package shall contain prestored fare tables which, together with the encoded station of entry, allows the exit console to determine the fare.

        1) If the value of a BART ticket is less than the required fare, the ticket shall be returned unaltered to the customer and the message “Underpaid - Go To Addfare” shall be displayed and the barrier shall remain closed.

2) If the remaining value of a BART ticket is equal to the fare required, the ticket shall be captured, the message “Exact Fare-Ticket Not Returned” shall be displayed and the barrier shall open. The ticket shall be encoded $0.00 value and 00.00 printed on the last print line, and the ticket shall be sent to the discard bin.

3) If the remaining value of a Student ticket is equal to or less than the required fare, the module shall calculate the difference and store this “uncollected fare” in the data storage as specified herein. The ticket shall be encoded and printed with $0.00 value and returned to the patron, and the barriers shall open. It shall be possible to deactivate the “uncollected fare” function by a parameter change locally in the service keypad or remotely from DAS or EME.

4) If the remaining value of the ticket is greater than the required fare, the module shall calculate the new ticket value by deducting the fare, and encode the new ticket value.

3. Encode Remaining Value: After calculation of the fare, the ticket shall be transported to the write head to encode the new remaining value onto the magnetic stripe.

4. Verify Encoded Data: The transport assembly shall move the newly encoded ticket to a “verify” station to verify the encoded data. If the verification fails, the ticket shall be returned to the customer and the message “See Agent” shall flash on the display. If three “write” failures occur consecutively, the console shall place itself in “Out of Service” mode.

5. Printing of Remaining Value:

   a. The printing shall be capable of being configured to print a fifth digit for the hundreds field within the designated print area.

   b. If the printing on the BART-Blue or Student ticket has reached 21 lines and there is value remaining, a new ticket shall be issued to replace the original ticket. The new ticket shall be obtained from a supply of tickets located near the beginning of the transport. The ticket supply and feed mechanisms shall be identical in functional concept to the same equipment in the TVM, and use the same ticket rolls.

6. Ticket Return: If the verification check is valid and printing of the remaining value has been completed, the transport assembly shall move the ticket to the exit slot and the message “Take Ticket” shall be displayed. The ticket shall protrude approximately 1.5 inches above the top of the console in the exit bezel and shall be held in place by a holding brake until it is retrieved by the customer.

7. Alternative to a magnetic stripe ticket, the customer may tag a smart card on the CID to initiate exit transaction at the fare gate. The customer shall leave the card on the CID for the duration of the transaction. The same validity checks and encoding for magnetic tickets shall apply for smart cards, modified to accommodate the technical differences between tickets and smart cards. No printing shall be possible on the smart card, and the smart card shall not be captured.

8. The fare gate shall provide audible indication:

    a. Two seconds after the smart card has been successfully processed for exit and is still tagged,

    b. If balance falls below a pre-established threshold, and

    c. When it fails to process the card.

9. Discount fare media indication. Once the ticket type or card type is acquired from the fare media, the fare gate shall visually indicate the discount ticket type, including senior, youth, or disabled tickets. The visual indication shall be visible on the End Display for an individual standing 20 feet away from the fare gate either in the entry or exit direction of the fare gate.

10. Barrier Opening: Upon retrieval of the protruding ticket from the exit slot by the customer, or the completion of a smart card transaction, the barriers shall open. The passage of the customer shall be without unnecessary stops or delays. Only one customer shall be allowed to pass per valid ticket.

11. Captured Tickets

    a. Tickets that are captured shall:

        1) Have their value reduced to zero magnetically;

        2) Have four zeros printed on the last line of the print column or have the word “VOID” printed in large fonts lengthwise down the remaining value print column; and

        3) Be diverted to the captured ticket bin.

    b. The capacity of the captured ticket bin shall be approximately 200 cubic inches.

    c. Smart cards shall not be captured.

12. Date/Time Code: Patron time within the BART system, as determined by the entry gate date/time codes and day/time at the exit gate shall be limited three hours. If there is a fault with the time encoded on the ticket or if such occurrences as excessive train delays, cause the customer to exceed the three-hour limit, a day/time override capability shall be given to the station agent. The override command shall make the exit ticket processing module ignore the day/time check at the exit gate and allow the customer to exit the system with an otherwise valid ticket.

13. Out of Service: When the console is not functioning properly and is in its out-of-service mode, the message “Out of service” shall be displayed on top of the console and the corresponding End Display for Entry Prohibited shall be lit. In this mode, the console shall not accept a ticket into its transport nor accept a smart card tag.

2.06 REVERSIBLE CONSOLE (R)

A. The reversible console shall contain one entry ticket processing located at one end of the console and exit ticket processing module at the other end. The applicable module shall be activated in accordance with the direction selected for the adjacent aisle. The electronics shall be identical between the consoles, and they shall also be switched to match the direction selected. All of the entry and exit functions indicated are applicable to the reversible console. Changing the direction of an aisle locally shall be accomplished by a key switch located on the paid area end of the appropriate gate console, by a keypad located within the gate console, and from DAS and EME. After a power-off or an all barrier open command, the gates shall return to their last direction upon return to service.

2.07 GATE BARRIER

A. A gate barrier shall be formed by two bi-parting leaves located in adjacent consoles that are pivoted towards each other to form a closed aisle. The barrier shall conform to the following requirements:

1. The drive mechanism shall be either pneumatic or electric.

2. Closing Force. The force to close a barrier shall be such that a customer may stall the closing motion with a force of 10 plus or minus 2 pounds per leaf. The force shall be applied at the maximum travel of the leading edge at any time throughout its stroke. At gate-closed position (leaves are fully extended) the force shall be 30 plus or minus 1 pound per leaf.

3. Response Time. Each leaf moving simultaneously shall move through its full travel within 0.45 to 0.75 second.

4. Alarm. Forcing any barrier leaf or both leaves to open beyond three inches from their normally closed condition shall activate an audible alarm, in that particular aisle, with an adjustable sound level from 65 dbA to 80 dbA measured ten feet from the console. The alarm shall sound as long as the barrier is being forced open.

5. Mechanical Strength

    a. A closed barrier shall be able to sustain repeated impact in both directions of travel without permanent deformations or damage. The impact shall be equivalent to a 200 pound object moving at three mph and striking the barrier at the centerline of the aisle. A 300 pound downward force applied on top of a leaf shall cause no damage.

    b. When in the closed position, each leaf shall withstand a force of 50 pounds applied horizontally, in the direction of passage. The force when applied at the point of greatest leverage shall not cause more than 0.125 inch deflection or deformation of the leaf.

    c. The leaves shall be located as indicated in the Contract Drawings. Leaves shall be integrated into the console such that all loads generated by barrier

operation shall be transmitted through the console base and into the station floor.

6. Clearance. The gap between two fully extended leaves shall be 2 plus or minus 0.25 inches.

7. Barrier Height. The lowest point at the top of the fully extended leaves shall be at least 60 inches from the floor. The lowest point at the bottom of the fully extended leaves shall be at most 6 inches from the floor.

8. Fabrication: Drawings of existing equipment will be made available to the Supplier to ensure conformance of the new equipment to the existing design. Each leaf shall be approximately triangular in shape and shall be molded from closed cell polyurethane, integral skin, foam with urethane foam finish. A one-piece aluminum internal leaf insert shall serve as the polyurethane mounting surface. The thickness of each leaf shall be 2 plus or minus 0.25 inches. The color required shall be orange which shall match a Rohm & Haas #2564 color chip.

9. Barrier Logic: Sensors shall be located within the consoles to detect the customer's relative location as they pass through the aisle. Based on sensor data, the barrier logic in the gate consoles shall perform the following functions:

    a. Control the barriers by detecting customer passage, prohibiting the possibility of barrier closure on the customer, and deterring the possibility of more than one customer traversing the gate with a single ticket.

    b. Control the barriers such that they are prevented from closing, to the extent possible, prior to a customer passing through with a parcel, briefcase, suitcase, umbrella, and the like.

    c. Open barriers upon receipt of an "Emergency Barrier Open" command from DAS, Station Agent Booth, or through the station's fire alarm control panel or pull station. For interface, refer to District Technical Manuals, SCADA System Function Description

    d. Upon loss of power, the barriers shall automatically open and remain open.

    e. Upon restoration of power, the barriers shall return to their normally closed status.

    f. The barrier operation shall not be affected by packages, canes, briefcases, umbrellas, and other objects that are less than six inches in length in the direction of travel and at a nominal height of three feet above the floor.

    g. Entry into an open aisle from the closed direction shall cause the barrier to close and re-open only when the aisle is again cleared.

    h. When the barrier is open and if the reverse direction side of the aisle is obstructed, the barrier shall close. Normal barrier operation shall return when the reverse side is cleared and a valid ticket is retrieved from the exit slot.

i. An obstruction lasting longer than eight seconds shall cause the aisle to go out of service. This time shall be adjustable. When the obstruction is cleared, the gate shall automatically return to service.

j. Monitor the status of the aisle sensors. If any sensor is blocked, the gate shall not accept a ticket into its ticket transport.

10. Leaf Relocation and Adjustment. It shall be relatively easy to relocate or adjust the leaves between the two possible locations on either side of the console in order to align properly with the leaf in the adjacent console to form an appropriate barrier.

2.08 FARE BANKING

A. Banking refers to the transaction whereby tickets or a combination of tickets and smart cards are processed by the gate console, one after the other, up to a maximum of ten, followed by the banked customers walking through an open aisle. After the last banked customer has passed through, the barrier shall close automatically and revert to its normal operating mode. During banking, the barrier shall remain fully opened, without any movement or hesitation.

2.09 TRANSACTION TIME

A. The transaction time for individual transactions shall be as follows:

1. A maximum of 0.90 second for an entry console to complete a transaction from time ticket is inserted to time ticket is returned.

2. A maximum of 0.90 second for an exit console to complete a transaction from time ticket is inserted to time ticket is returned to the customer.

3. A maximum of 0.30 second for the barrier to open from the time ticket is retrieved from ticket slot.

4. Logic Reset Time: After maintenance service, the time for the gate console to return to service after the console doors are closed shall not exceed three seconds.

2.10 GATE CLOCK

A. The gate clock shall have the capability of being set locally, synchronized to a Network Time Protocol time source, and synchronized remotely from the DAS and shall provide the following time and date information:

1. Time Tagging. Each transaction and event shall be time tagged.

2. Time Code for the BART Ticket. Each transaction shall be tagged with a time code with resolution of one minute during the day.

3. Day/Month Code for the BART Ticket: The day and month of the transaction shall be encoded on the ticket.

4. Peak/Off Peak Fare: The clock shall automatically control the time periods selected for these two categories of fares. It shall also be possible to manually select the fare categories from the local maintenance keypad and from EME.

5. Time/Date Information for Student, and for other tickets to be introduced by BART in the future, consisting of:

    a. Time in hours, minutes, and seconds in both 12-hour and 24-hour formats

    b. Julian date

    c. Day of week

    d. Day of month

    e. Month

    f. Year

    g. Leap Year

    h. Daylight Savings Time

    i. Month code

    j. Year code

2.11 TICKET TRANSPORT ASSEMBLY

A. The ticket transport assembly for the gate consoles shall conform to the same basic concept and other appropriate features as indicated for the TVM as specified in Section 34 50 13, Ticket Vending Machines, and AFM as specified in Section 34 50 10, Fare Collection System.

2.12 MICROPROCESSOR ASSEMBLY

A. The microprocessor assembly shall control operating functions of the fare gate. It shall control the performance and timing of all other assemblies, sub-assemblies, modules and displays in the faregate; and control and monitor the barriers and passenger aisle. The operating system, data and application programs shall be inherent in each microprocessor assembly to allow each faregate aisle to operate as a stand-alone aisle. The failure of any microprocessor assembly in the array shall only affect the gate aisle controlled by that microprocessor assembly. Other aisles shall remain operational. There shall be no dependency on the communication link. It shall be possible to download configuration parameters, faretables, and applicable software programs into the gate consoles remotely from the EOW and locally from the PC Notebook. The microprocessor assemblies in the gate consoles shall be identical and interchangeable. The microprocessor assembly shall satisfy the requirements of either the entry or exit mode upon selection of one or the other by a local or remote switching command. The microprocessor assembly shall monitor the fare gate such that a change in aisle direction shall not be allowed during a transaction or during an apparent queue situation.

B. Chip Quality: Same requirements as for the TVM, as specified in Section 34 50 13, Ticket Vending Machines.

C. Data Storage

1. Non-Volatile RAM Storage: Non-volatile RAM storage shall be provided to store critical data in non-resettable registers to serve as backup in the event of failures in the communication link or the DAS. The RAM storage shall record ticket transaction and event data as they occur, and shall be designed to be polled from DAS and to allow local extraction of stored data when connected to the specified PC Notebook. The RAM storage shall be divided into two partitions: the current period and the previous period. The current period shall contain the data since the gate was last polled by the DAS or the PC Notebook. The previous period shall contain the last polled data. The RAM storage shall be adequate to store the current and previous period accumulated data for at least 30 days. For the individual ticket transaction data, the RAM storage shall have the capacity to store 50,000 transactions or three days' worth of data, whichever is greater, for both the current and previous period. Upon loss of power, the stored data shall remain intact for at least 30 days. The RAM storage shall be adequate for the storage capacity indicated plus a reserve of 300 percent of the capacity used. Expansion shall be possible with the simple addition of memory boards or chips. Hard disks shall not be used for faregate data storage.

2. Data to be Stored: Data to be stored by the gate consoles shall include but not be limited to the following:

    a. Entry Console

        1) Accumulated number of tickets/smart cards by type.

        2) Accumulated number of ticket jams.

        3) Accumulated number of events by event type.

        4) Real-time and polled data as defined hereunder.

    b. Exit Console

        1) Accumulated number of tickets/smart cards processed by type.

        2) Accumulated value of fares deducted by total and by ticket/smart card type.

        3) Accumulated number of ticket jams.

        4) Accumulated number of tickets dispensed from ticket supply.

        5) Total uncollected fare (Last Ride Bonus).

        6) Accumulated number of events by event type.

        7) Real-time and polled data as defined hereunder.

D. Data Interface:

1. Real Time. Real time data shall be transmitted to the DAS as soon as the events occur, in real time. The data to be transmitted shall include but not be limited to

the data indicated below. The data transmission process shall be accomplished with no degradation to system performance and transaction times.

a. Entry data for each ticket transaction:
    1) Console identification number;
    2) Station location;
    3) Date;
    4) Time in hour, minute, second;
    5) Valid entry;
    6) Ticket/smart card type;
    7) Ticket/smart card serial number;
    8) Remaining value of ticket/smart card; and
    9) Smart card data.
b. Exit Data for each ticket transaction:
    1) Console identification number;
    2) Station location;
    3) Date;
    4) Time in hour, minute, second;
    5) Ticket/smart card type;
    6) Ticket/smart card serial number;
    7) Station of entry;
    8) Fare deducted;
    9) Remaining value of ticket/smart card;
    10) Uncollected fare (Student only);
    11) Ticket replacement;
    12) Valid exit;
    13) Smart card data;
    14) Captured ticket (exact fare); and
    15) Captured ticket (ticket printed on last line).
c. Events:
    1) Console identification number;
    2) Station location;
    3) Date;
    4) Time in hour, minute, second;
    5) In service;

6) Out of service;
7) Direction of travel (entry or exit);
8) Event code or Failure code;
9) Near full discard bin indication;
10) Faregate barrier open/close status;
11) Entry/exit override on/off status;
12) Time/day override on/off status;
13) Time/date of occurrence;
14) Faregate in maintenance mode;
15) Personnel ID code; and
16) Performed function code.

d. Equipment Condition and Summary Data:

1) Number of failure/malfunction incidents by type;
2) Number of service and warning incidents by type;
3) Number of access to ticket handling mechanism;
4) Number of legitimate entries
5) Number of forced entries
6) Number of tickets in reject bin; and

2. Polled Data. Polled data for either the current period or the previous period shall be sent to DAS upon request (poll). The data shall include but not be limited to the following:

a. Console identification number;
b. Station location;
c. Date;
d. Time in hour, minute, second;
e. Cumulative number of entries since last successful poll, by ticket/smart card type;
f. Cumulative number of exits since last successful poll, by ticket/smart card type;
g. Amount of fare collected since last successful poll, by ticket/smart card type;
h. Uncollected fare (Student) since last successful poll;
i. Cumulative fare collected, by ticket/smart card type;
j. Cumulative uncollected fare (Student);
k. Complete list of events with date and time since last successful poll; and

l. Entry/exit data for each transaction and Event Data as indicated herein.

3. Commands. Commands shall be executable from DAS. In the event of loss of communication with the DAS, these commands shall be executable on a local basis for an array, preferably, or individual gate console from the PC notebook or the maintenance keypad. The commands shall include but not be limited to the following:

   a. Change the direction of an individual aisle;

   b. Change the direction of an array of gates;

   c. Place a selected gate in or out of service;

   d. Place a selected array in or out of service;

   e. Open or close an individual aisle;

   f. Open or close an array;

   g. Override the entry/exit check;

   h. Override the day/time check;

   i. Synchronize the clocks;

   j. Request poll; and

   k. Poll fare gate.

4. Downloading. Gate parameter and configuration files shall be downloadable from the EME to an individual console or a group of consoles. The data shall include but not be limited to the following:

   a. Fare tables; and

   b. Changes to system variables.

2.13 MAINTENANCE MODE

A. Each console shall have a maintenance mode switch. When in the maintenance mode, a fare gate, either entry or exit, shall only accept a maintenance mode ticket. When a maintenance mode ticket is processed, all functions except the entry/exit check shall be performed for that type of ticket except that the transaction as stored in the non-volatile memory and transmitted to DAS shall be identified as a Maintenance Mode Transaction. A mechanical switch shall be provided to place the unit in maintenance mode. An internal indicating light or display shall indicate that the fare gate is in maintenance mode. The console shall automatically return to revenue mode when top lid is closed. The faregate, when in Maintenance Mode, shall also process a “7F” ticket.

2.14 MAINTENANCE DISPLAY AND KEYPAD

A. An LED, LCD, or equivalent display shall be used along with an internally mounted keypad to enable troubleshooting of the console. The keypad shall have the

capability to access diagnostic function and perform such tasks as exercising the logic networks and mechanical modules.

B. Safeguards shall be employed to assure that changes to the software cannot be performed unless it is performed by authorized personnel, and a secure and pre-approved procedure is followed.

C. Failure codes shall be displayed. Failure codes for each type of gate console shall encompass failure codes reported by each subcomponent. Diagnostics of the micro-sub logic and memory storage shall be continuous and automatic. Diagnostics shall also be possible through the specified PC notebook. The failure codes with brief text descriptions shall be defined at preliminary design review (see Section 34 50 10, Fare Collection System).

D. A standard serial or parallel port shall be provided to connect to the PC Notebook for additional testing, for local printouts of statistical data, or for downloading the data in RAM, locally when necessary.

2.15 LOSS OF ENCODED DATA

A. In case of partial loss of encoded data on the magnetic stripe, the entry and exit ticket processing modules shall process tickets under the following conditions:

1. BART and Student: Tickets under the following conditions shall be processed provided that the following acceptance criteria are met:

   a. One partially erased VEND word.

   b. One partially erased VEND word, and one partially erased DATA word.

   c. One partially erased DATA word.

2.16 EXIT GATE PRINTER

A. The printer in the exit gate shall print the remaining value of the ticket in the column provided, and shall print required information on replacement tickets. The printer shall be either a dot-matrix impact printer or a thermal printer, and shall conform to the printer requirements specified in Section 34 50 13, Ticket Vending Machines for the TVM.

2.17 ACCESSIBLE FARE GATE

A. General. The AFG shall permit wheelchair customers to gain access to the paid area. It shall also serve as a service gate, emergency exit gate, and as a backup to the regular gate array, when required, and shall provide convenient access to customer with large packages, bicycles, strollers, and the like.

B. Accessible Gate Console. The accessible gate console shall be of same construction as the regular reversible gate console with the exception of the following requirements:

1. The width of the aisle shall be 42 inches minimum.

2. The barrier shall consist of either electrically operated telescopic bi-parting leaves, a single electrically operated swing gate, or electrically operated bi-parting swing gates.

3. Access to internal components shall be possible from either side to permit the installation of either side against a wall.

4. The ticket entry bezel shall be epoxy coated a bright red or equal. The bezel design shall be subject to BART approval.

5. The international accessible sign shall be affixed to both ends of the console just below the arrow.

6. Where applicable, the DAS and Hardwired Communication Interface shall be identical to the regular reversible gate console.

7. Ticket processing shall be identical to the regular reversible gate console except that the console shall automatically set itself into the proper directional mode depending on whether the entry or exit slot has sensed the ticket insertion. Once a slot has sensed a ticket insertion, the other slot shall not accept a ticket insertion until the transaction from the first insertion is completed and the passenger has cleared the aisle.

8. The gate console shall return the ticket to the slot into which the ticket was inserted.

9. The top display shall be located so it can be seen either by a walking customer or by a customer in a wheelchair. A side display shall be provided to accommodate wheelchair customers.

10. The gate console shall be designed to be placed at the end of an array, either against a wall or against a low barrier perpendicular to the array.

11. The gate console shall be designed to allow for either left or right hand ticket insertion.

C. Gate Barrier for Telescoping Bi-parting Leaves. The gate barriers for the telescoping bi-parting leaves gate concept shall conform to the requirements of the barriers for the regular gate except for the following:

1. The drive mechanisms shall be electrically operated.

2. Each barrier shall be approximately triangular in shape and shall consist of no more than two telescoping leaves.

D. Enclosure. The enclosure shall support the gate barrier and shall contain the mechanical closure mechanism and the barrier damping devices. All components shall be located within the enclosure. Power and communication cables to under floor ducts shall be required. Anchoring provisions into the structural concrete floor shall be provided as required.

E. Alarms: Alarm conditions shall be transmitted to DAS.

1. Audible Alarm. The accessible gate console shall contain an audible alarm with a sound level of 80 dbA maximum, measured 10 feet from the barrier. The sound level shall have a continuous adjustment or settings possible at 25, 50, and 75 percent below the maximum level. An externally accessible key switch shall be provided to deactivate the alarm. Alarm shall sound under the following conditions:

    a. The barrier is forced open.

    b. The barrier fails to close after a customer passes or within an adjustable time period between 5.0 and 25.0 seconds after a valid opening. The alarm shall sound until the barrier is closed.

2. Intrusion Alarm. A “barrier forced open” condition shall cause an intrusion alarm to be sent to DAS as a real-time event, and to the Hardwired Communication Interface in the form of a relay contact closure.

3. Barrier Logic. The AFG barrier logic shall perform the following functions:

    a. Control the barrier by detecting customer passage, prohibiting the possibility of barrier closure on the customer.

    b. Control the barrier such that it is prevented from closing to the extent possible, prior to a customer passing through with large packages, a bicycle, a stroller, and the like.

    c. Open the barrier upon receipt of an “Emergency Barrier Open” command from the Hardwired Communication Interface, SCADA or DAS.

    d. Upon loss of power, the barrier shall automatically open and remain open. Upon restoration of power, the barrier shall automatically close.

    e. Conform to the fare banking requirements specified herein.

F. Fabrication Materials. The frame of the barrier and the gate cabinet shall be constructed of stainless steel plates and tubing in accordance with ASTM A240/A240M and ASTM A269/A269M, respectively, type 304L, number 4.0 finish, fully welded. All signs shall be covered with polycarbonate or equal to be scratch resistant. The transparent barrier shall be a hard and durable polycarbonate such as Lexan MR-5000 or approved equal.

G. Mechanical Strength. The closed barrier and mounting post shall be able to sustain impacts in both directions of travel without deformations or damage. The impact shall be equivalent to a 200 pound customer in a wheelchair moving at 4.0 mph and striking the barrier at the centerline of the aisle.

2.18 SMART CARD INTERFACE DEVICE (CID)

A. CID to read contactless fare media shall be provided on all gates. The module shall communicate with contactless cards and mobile devices.

B. Encoding format and processing requirements by the gates shall be in accordance with MTC Clipper® Card Specification, BART Only Smart Card Specification (see Section 34 50 10, Fare Collection System), and an Open Payment specification as indicated.

C. The CID shall be located at the top of the entry, exit or reversible console, or on the side of the accessible fare gate console to conform with ADA requirements. A customer shall be able to present the fare media without having to remove the media from a wallet or a purse.

2.19 BATTERY BACK-UP

A. The battery back-up shall meet the same requirements specified for the TVM in Section 34 50 13, Ticket Vending Machines, except that the provisions for power switches shall not apply to fare gates.

PART 3 – EXECUTION

For installation refer to Section 34 50 11, Fare Collection Equipment Installation.

END OF SECTION 34 50 16

SECTION 34 50 19

ADDFARE MACHINES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Addfare Machines (AFM)

1.02 RELATED SECTIONS

A. 34 50 10 Fare Collection System

B. 34 50 11 Fare Collection Equipment Installation

C. 34 50 13 Ticket Vending Machines

D. 34 50 16 Fare Gates

1.03 MEASUREMENT AND PAYMENT

A. Measurement: Addfare machines will be measured for payment as a lump sum unit acceptably installed and tested for compliance.

B. Payment: Addfare machines will be paid for at the Contract lump sum price for addfare machines or as part of the lump sum price for Fare Collection System Work, as determined by the lump sum measurement specified above, as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. Payment Card Industry (PCI) Security Standards Council

1. Pin Transaction Security (PTS) Point of Interaction (POI)

2. Point-to Point Encryption (P2PE) Solution Requirements and Testing Procedures

B. EMVCo (Europay, MasterCard and Visa) Specifications

1. Integrated Chip Card to Terminal Interface

2. Security and Key Management

3. Application

C. Americans with Disabilities Act (ADA):

1. Americans with Disabilities (ADAAG)

D. California Code of Regulations (CCR):

1. CCR, Title 24 California Building Code

E. San Francisco Bay Area Metropolitan Transportation Commission (MTC):

1. Clipper® Card Specification

1.05 SUBMITTALS

A. Refer to Section 34 50 10, Fare Collection System, for submittal requirements.

PART 2 – PRODUCTS

2.01 GENERAL

A. Functionality: The AFM shall perform the following functions:

1. Upgrade an undervalued BART Blue ticket to the minimum fare required to exit the station, using cash;

2. Reload Clipper® Card fare media up to the minimum fare required to exit the station using cash;

3. Allow the customer to select the amount to load on an existing fare media.

4. Pay for parking by entering a stall number for validation, using either magnetic ticket store value or cash, credit or debit card).

5. Accept credit and debit cards with either magnetic stripe, EMV (Europay Mastercard Visa) compliant chips, contactless payment card, or mobile device;

6. Accept one and five dollar bills, nickels, dimes, quarters, dollar coins, and optionally ten and twenty dollar bills;

7. Return nickels, dimes, quarters, dollar coins and optionally bills for change on cash transactions;

8. Provide change up to $4.95. The quantity of change dispensed shall be programmable locally in the service keypad or remotely from EME;

9. Make change without purchase for one $1.00 bill;

B. Design: The AFM shall be of same design, construction, software and operating features to the ticket vending machines (TVM) specified in Section 34 50 13, Ticket Vending Machines, except as modified herein.

C. Drawings: The Contract Drawings depict examples of front panel features and equipment dimensions. The examples are provided to the Supplier as the basis for developing its design and shall not be construed to be complete. The Supplier shall

be responsible for the design of the AFM and their compliance to the requirements specified herein.

2.02 COMPATIBILITY

A. Functional and physical compatibility requirements with existing AFM shall be the same as those specified for TVM's in Section 34 50 13, Ticket Vending Machines.

2.03 CUSTOMER INTERFACE AND HUMAN FACTORS:

A. The requirements for customer interface and human factors shall be the same as for TVM as for TVM as specified in Section 34 50 13, Ticket Vending Machines.

2.04 FRONT PANEL ASSEMBLY

A. The operating features on the front panel of the AFM are indicated on the Contract Drawings. Requirements for message display unit, soft keys, out-of-service annunciator, coin bezel, coin return cup, bill bezel, bill return, ticket slot, access lock, and front panel graphics shall be the same as for the TVM as specified in Section 34 50 13, Ticket Vending Machines, except as modified herein.

B. Message Display Unit (MDU): Messages shall be adapted to the functions of the AFM.

C. Numeric Keypad: A numeric keypad is required to allow customers to enter a parking stall number for fee-based parking validation. The keypad shall also serve as the PIN entry device for debit card transactions. When used to enter the debit card PIN, the key pad shall encrypt the PIN prior to transmitting the data to the Single Board Computer. Parking stall numbers shall be transmitted unencrypted.

D. Bill Bezel: AFM shall accept $1, $5, $10 and $20 bills. The bill bezel shall be constructed of stainless steel or cast aluminum and formed with a ledge and side guides such that the customer can hold the bill down and slide it into the bill validator entry slot to minimize any tendency to skew. No gaps shall exist between the bezel and entry slot that could divert the bill into the inside of the AFM. The bezel shall be of sufficient strength to withstand minor acts of vandalism and shall be a replaceable module. The bezel shall be designed to reduce and prevent potential for fraud through tampering. Graphics, located on the bezel below the entry slot, shall illustrate the correct orientation of the bill. Graphics shall be engraved. The bezel shall not extend more than one and one-quarter inch from the surface of the front panel and shall be affixed to the bill validator and not to the front panel. Upon rejection, bills shall be returned through the bill bezel. The bills shall protrude at least two inches, and shall be held until forcibly retrieved by the customer.

E. Bill Return: Upon cancellation of a transaction, the escrowed bills shall be returned through a separate bill return slot. The bills shall protrude at least two inches, and be held until forcibly retrieved by the customer. In addition, transactions requiring change return many optionally return bills as change, returning change with the best combination of bills and coins.

F. Cancellation: The “Transaction Canceled” message shall be displayed on the MDU conditions:

1. Coin or bill escrow capacity has been exceeded.

2. Power failed before the total amount of money required was inserted.

3. Greater than $1.00 is inserted for a “Change Only” transaction.

4. Jammed ticket.

G. Front Panel Graphics: shall be designed to be sufficiently different in appearance from the TVM to enable customers to readily identify the two types of equipment.

H. Receipt Printer. The AFM shall be equipped with a receipt printer that prints a receipt for the following scenarios:

1. Upon request, receipt for a successful credit card or debit card transaction

2. Receipt for a failed cash transaction for refund claim

3. Receipt for revenue service access

4. Receipt for parking validation transactions

I. Smart Card Reader (see Article 2.14 in Section 34 50 13, Ticket Vending Machines) for Reload: the AFM shall be equipped with a customer-facing Smart Card Reader that allows the customer to add value to an existing smart card.

2.05 TRANSACTION TIMES

A. Transaction times shall be measured based on the total time for ten consecutive identical transactions conducted by trained personnel, divided by the number of transactions.

B. Undervalued Ticket. The AFM shall complete the upgrading of a ticket undervalued by $2.40 in less than 15 seconds for the following denominations of money inserted:

1. Three one dollar bills ($0.60 in change returned).

2. Two one dollar bills, one quarter, one dime, and one nickel.

3. One five dollar bill ($2.60 in change returned).

C. Clipper® Card: Transaction time for a Clipper® Card loading shall be the same as for the TVM, as specified in Section 34 50 13, Ticket Vending Machines.

2.06 MICROPROCESSOR ASSEMBLY

A. The requirements for chip quality, data storage, and data interfaces shall be the same as those for the TVM as specified in Section 34 50 13, Ticket Vending Machines, except as modified herein.

B. Data Storage.

1. AFM shall gather the following data.

a. Cumulative Sales Data: Each storage partition (current and previous) shall maintain a record of cumulative sales data including:

1) Total sales revenue;

2) Revenue from currency by denomination;

3) Total number of change-only transactions;

4) Number of tickets or Clipper® cards by type addfared by currency;

5) Value and number of ticket or Clipper® card addfares by ticket type;

6) Value and number of Clipper® Card reloads;

7) Number of parking fee payment transactions; and

8) Value of parking fee payment from tickets and from currency.

b. Individual Ticket Transaction Data: Each storage partition (current and previous) shall maintain a record of each individual addfare and Clipper® Card reload transaction. For each transaction, the recorded data shall include but not limited to:

1) AFM identification number;

2) Station location;

3) Date and time of transaction;

4) Transaction number;

5) Amount of money patron paid;

6) Identification of change-only transaction;

7) Value of ticket before addfared or Clipper® Card before reloaded;

8) Value of ticket after addfared or Clipper® Card after reloaded;

9) Value of addfare that AFM wrote to ticket or Clipper® Card;

10) Ticket value used for parking payment;

11) Ticket or Clipper® Card type and serial number;

12) Currency accepted by denomination;

13) Coins returned by denomination;

14) Coins returned by hopper by denomination; and

15) Parking stall number entered by the customer and validated by the AFM.

c. Equipment Summary Data: Each storage partition (current and previous) shall maintain a record of Equipment Summary Data including but not limited to:

1) Number of failure or malfunction incidents by type
2) Number of access to Bill Vault and Bill Escrow
3) Number of access to Coin Vault, Coin Hoppers, and Coin Magazines
4) Number of access to ticket roll stocks
5) Number of legitimate entries
6) Number of intrusions and manipulation entries
7) Number of bills read but not accepted
8) Number of service and warning incidents by type
9) Amount of money in each revenue service component
10) Number of accesses to ticket handling mechanism

d. Equipment Event Data: Each storage partition (current and previous) shall maintain a record of each equipment event, including details for each transaction or media validation failure. The recorded data shall include but not limited to:

1) AFM identification number
2) Station location
3) Date and time of event
4) Type of Event
5) Failure Code
6) Operator ID, Security Level (if applicable)
7) Complete financial status of component (if applicable)

2. Storage Capacity: The data storage media (RAM, Hard disk or Solid State Disk) shall be adequate to store the current and previous Cumulative Sales Data and the Equipment Summary Data for at least 30 days. For the Individual Sales Transaction Data and the Equipment Event Data, the data storage media shall have the capacity to store 10,000 transactions or three days worth of data, whichever is greater, for both the current and previous period. The data storage media shall be adequate for the storage capacity indicated plus a reserve of 300 percent of the capacity used. If RAM storage is used, expansion shall be possible with the simple addition of memory boards or chips.

C. Data Interface. The data to be transmitted shall include the following as a minimum:

1. Real Time Data: The data indicated below shall be transmitted to the DAS as soon as the events occur. The data transmission process shall be accomplished with no degradation to system performance and transaction times.

a. Event Data:

1) AFM Identification number;
2) Station location;
3) Date, Time;
4) Operator ID, Security level;
5) Door open;
6) Door close;
7) Maintenance Mode On;
8) Maintenance Mode Off;
9) Coin box 85 percent full;
10) Coin box 100 percent full;
11) Supplemental hopper 10 percent full (5-cent);
12) Supplemental hopper 10 percent full (25-cent):
13) Supplemental hopper empty (5-cent);
14) Supplemental hopper empty (25-cent);
15) Bill vault 85 percent full;
16) Bill vault 100 percent full;
17) Ticket level low;
18) AFM in secondary mode; identify mode;
19) Failure code;
20) Intrusion Alarm;
21) Manipulation Alarm;
22) Rejection bin full;
23) Coin jam;
24) Bill Jam;
25) Complete financial status of the AFM every time the AFM door is opened;
26) Indication of low-ticket supply;
27) Indication of low-receipt supply;
28) Performed function code;
29) AFM in-service/out-of-service;
30) Hopper recharged;
31) Authorized entry;
32) Loss of power;
33) Configuration parameter change;
34) Component status and failure events.

b. Individual Sales Transaction Data: The data specified in Article 2.06.B.1.b shall be transmitted.

c. Treasury Service Data:

1) AFM ID number and location

2) Date, Time

3) Operator ID, Security level

4) ID of each revenue service component removed

5) ID of each revenue service component inserted

6) Number and type of bills/coins in each revenue service component removed

7) Unauthorized bill vault or coin box removal or insertion

d. Real Time Data: The data indicated below shall be transmitted to the DAS as soon as the events occur, in real time. The data transmission process shall be accomplished with no degradation to system performance and transaction times.

2. Polled Data: The AFM shall transmit the following data when polled

a. Summary of AFM condition: The stored Equipment Summary Data specified above.

b. Summary of Sales Transaction: The stored Cumulative Sales Data specified above.

c. Ticket Transaction Data: The stored Individual Ticket Transaction Data specified above.

d. Equipment Event Data: The stored Equipment Event Data specified above.

2.07 TICKET TRANSPORT MODULE

A. The ticket transport module shall encode the new remaining balance on the inserted magnetic stripe ticket upon completion of the add fare or parking transaction. The AFM shall not have a ticket supply, nor shall it print on the ticket.

2.08 FARE STRUCTURE

A. The AFM shall conform to the fare structure requirements specified in Section 34 50 10, Fare Collection System.

B. Parking fees shall be specified via downloadable configuration tables, and may be individually configurable for each station. Parking fees shall support time/day-based pricing.

2.09 OTHER REQUIREMENTS

A. Other requirements for the AFM shall be the same as those for the TVM as specified in Section 34 50 13, Ticket Vending Machines. This applies to maintenance mode, coin handling assembly, credit card module, audio, smart card reader, power supply management, external security and intrusion alarm, service keyboard, and downloading capabilities.

PART 3 – EXECUTION

For installation refer to Section 34 50 11, Fare Collection Equipment Installation.

END OF SECTION 34 50 19